PHYSICAL SCIENCES
Grade 10
TERM 1
RESOURCE PACK

Contents

WORKSHEETS

Topic 1: Matter and its Classification

WORKSHEET

MULTIPLE CHOICE QUESTIONS

1. What is the correct chemical name for the compound that has the chemical formula: $Fe_2(SO_4)_3$?

A. Iron sulfate

B. Iron sulfide

C. Iron(II) sulfate

D. Iron(III) sulfate (2)

2. Which one of the following is the correct formula for aluminium phosphate?

A. $A\ell P$

B. $A\ell PO_4$

C. $A\ell_3PO_4$

D. $A\ell(PO_4)_3$ (2)

3. Which of the following is the chemical formula for carbon tetrahydride?

A. CH

B. CH_2

C. CH_3

D. CH_4 (2)

4. Some table salt is fully dissolved in water. The result is:

A. a heterogeneous mixture.

B. a homogeneous solution.

C. a heterogeneous solution.

D. none of the above. (2)

5. Which one of the following statements correctly describes a pure substance?

A. It contains only one type of molecule.

B. It contains free atoms and molecules.

C. It contains many types of molecules.

D. It contains many types of free atoms. (2)

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LONG QUESTIONS

6. Refer to the table of information shown below, and answer the questions that follow.

Material	Magnetic	Electrical conductor	Thermal conductor	Thermal insulator	Element	Compound
Steel	yes	yes	yes	no	no	no
Glass fibre	no	no	no	yes	no	yes
Wood	no	no	no	yes	no	yes
Air	no	no	no	yes	yes	no
Copper	no	yes	yes	no	yes	no

6.1 Select a material which is suitable to use as ceiling insulation that keeps a home cool in summer and warm in winter. (2)

6.2 Select a material that is suitable for making magnets for an electric motor. (2)

6.3 Steel is neither an element nor a compound. What type of material is it? Explain your answer. (4)

6.4 Select the material which lies between the two panes of glass in double glazed windows. (2)

6.5 Select a material which would be suitable to make electrical wiring. Explain your answer. (3)

6.6 Explain why wood is a thermal insulator. (2)

6.7 Explain why steel is such an important material in today's world and give three instances where steel is used. (6)

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CONSOLIDATION EXERCISE

TOTAL: 36 MARKS

MULTIPLE CHOICE

1. Which one of the following is not a pure substance?

A. aluminium

B. tin

C. brass

D. iron (2)

2. Which one of the following is the correct chemical formula for potassium sulfide?

A. KS

B. K_2S_2

C. K_2S

D. KS_2 (2)

3. What is the correct chemical name for the compound $Ca_3(PO_4)_2$?

A. calcium phosphate

B. calcium(II) phosphate

C. calcium phosphite

D. calcium phosphorus oxide (2)

4. Consider the following three statements about metalloids.

I They are good electrical conductors.

II They are semiconductors.

III They are usually magnetic materials.

Which statement(s) is/are correct?

A. I only

B. II only

C. I and II only

D. All of I, II and III (2)

5. Which one of the following is a property of magnetic materials?

A. They are electrical conductors.

B. They are not affected by magnets.

C. They generally have low melting points.

D. They are usually non-metals. (2)

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LONG QUESTIONS

6. Tabulate three differences between a mixture and a compound. (6)

7. **7.1** What is meant by the density of a material? (2)

7.2 Why do metals generally have high densities? (3)

8. **8.1** Which of the following is/are heterogeneous mixtures?
- Iodine and water
- Iodine and ethanol
- Sugar and water (2)

8.2 How would you identify a heterogeneous mixture? (2)

9. Describe how you would test a material for each of the following properties?

9.1 Electrical conductivity

9.2 Thermal conductivity

9.2 Whether it is magnetic (9)

10. What happens to the electrical conductivity of each of the following materials as its temperature increases?

10.1 Metals

10.2 Metalloids (2)

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MARKING GUIDELINES

MULTIPLE CHOICE

1. D ✓✓ The sulfate ion has the formula SO_4^{2-} and there are three of them making a total charge of –6. So, the two iron ions must have a total charge of +6, therefore each of them has a charge of +3. Hence iron(III). (2)

2. B ✓✓ Aluminium ions have a charge of +3 and phosphate ions are PO_4^{3-}. Hence they combine in a ratio of 1:1. (2)

3. D ✓✓ tetra- means 4. (2)

4. B ✓✓ When table salt is fully dissolved in water, we cannot distinguish between the salt and the water. Thus the solution is homogeneous. (2)

5. A ✓✓ A pure substance contains only one type of particle. The term free atoms refers to individual atoms making up a substance, and not to atoms which are bound in molecules. (2)

LONG QUESTIONS

6. **6.1** Glass fibre is often used as thermal insulator above the ceilings in buildings.✓✓
The structure of glass fibre is such that are lots of pockets of air within the material and this serves to make it a good insulator. (2)

6.2 Steel is the only material that is magnetic. It makes strong magnets. ✓✓ (2)

6.3 Steel is an alloy ✓of a number of metals, it can be an alloy of iron, vanadium, and other metals, ✓depending on the type of steel. Metals do not react chemically with each other.✓ They form a mixture ✓ called an alloy. ✓ (4)

6.4 Air. ✓✓The outside layer of glass, which is in contact with the air outside is cold. The layer of glass on the inside is in contact with the warm air indoors and is at the same temperature. The air that is in contact with this second pane, is a good insulator and prevents energy from the inside from passing to the outer pane, thus retaining warm air. (2)

6.5 Copper. Besides being a very good electrical conductor✓copper is also ductile✓ i.e. it can be drawn out into thin wire.✓ (3)

6.6 The structure of wood is such that there is a lot of air trapped in the structure.✓Air is a good thermal insulator.✓ (2)

6.7 Steel is strong✓ and can be shaped into many different types of material such as thin sheets and car panels.✓ It also does not corrode easily.✓

Steel is used in structural engineering such as buildings, bridges, cranes etc.✓

It is also used in making panels for car bodies. ✓

It can be used for making specialised tools which require hardness and durability.✓

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It is used in making the hulls and other structures of ships.✓
(Any three – including other reasonable uses not mentioned here.) (6)

CONSOLIDATION EXERCISE

TOTAL: 36 MARKS

1. C. ✓✓ Brass is an alloy of copper and zinc – it is thus a mixture. (2)

2. C. ✓✓ A potassium ion is K^+ and a sulfide ion is S^{2-}. It needs two potassium ions to balance the charges. (2)

3. A. ✓✓ Calcium can only have a charge of +2 so we do not put in the Roman numeral (II). (2)

4. B. ✓✓ The metalloids are not good conductors of electricity under all conditions. They only conduct electricity under certain conditions. They are also not magnetic materials. (2)

5. A. ✓✓ All metals conduct electricity and magnetic materials are all metallic. (2)

6.

PROPERTIES			
Mixture	Contains two or more materials in any ratio. ✓	Contains two or more materials that do not combine chemically. ✓	Mixtures can be separated by physical means. ✓
Compound	Contains two or more elements combined in specific ratios. ✓	Contains two or more elements that combine chemically. ✓	Compounds can only be separated into their elements by chemical means. ✓

(6)

7. **7.1** The density of a material is the mass per unit volume. ✓ ✓ (2)

7.2 Metals have atoms that are packed very closely together.✓ This means that there is a large amount of matter ✓packed in every unit of volume.✓ (3)

8. **8.1** Only iodine and water. ✓ ✓
Iodine crystals sink to the bottom of a test tube of water and are clearly visible. Iodine dissolves in ethanol to form a homogeneous solution which is pinkish in colour. Sugar dissolves in water to form a clear homogeneous solution. (2)

8.2 A heterogeneous mixture is one in which two phases of matter can be clearly observed. ✓ ✓ (2)

9. **9.1** Set up an electric circuit with a battery, two leads connected to the terminals of the battery and a light bulb.✓ Connect the free ends of the leads to either end of a piece of the material to be tested.✓ If the light bulb glows, the substance is an electrical conductor. ✓ (3)

9.2 Take a long narrow piece of the substance to be tested. Smear molten candle wax on one end and let the wax cool so that it is solid.✓ Heat the other end gently with a candle flame.✓ The quicker the wax melts, the better the substance serves as a thermal conductor.✓ If the wax doesn't melt, it is a thermal insulator.✓ (4)

9.3 If the material is attracted to a permanent magnet it is magnetic. ✓If not, it is non-magnetic.✓ (2)

10. **10.1** Metals become poorer conductors the warmer they get.✓ (1)

10.1. Metalloids become better conductors as their temperature increases.✓ (1)

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Topic 2: States of Matter and the Kinetic Molecular Theory

WORKSHEET

MULTIPLE CHOICE

1. Select the correct statement. While a substance is changing from a solid to a liquid:

A. its particles move closer together.
B. the kinetic energy of its particles decreases.
C. the interparticle forces become weaker.
D. its particles move less. (2)

2. Select the correct statement. When a substance undergoes a change of state from one state to another:

A. it remains the same substance.
B. its chemical composition changes.
C. it becomes a different substance.
D. there is no change in the strength of the interparticle forces. (2)

LONG QUESTIONS

3. Copy and complete the following table regarding the properties of the three states of matter.

	SOLID	LIQUID	GAS
Strength of intermolecular forces			
Spaces between the particles			
Movement of the particles			

(9)

4. Explain why the temperature of sulfur remains constant while it is melting. (4)

5. Water has a higher boiling point than alcohol. Give an explanation for this observation. (4)

6. Write down three of the assumptions of the kinetic molecular theory. (3)

7. In terms of the kinetic molecular theory describe the changes that occur in the particles of a substance when it changes from a liquid to a gas. (6)

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CONSOLIDATION EXERCISE

TOTAL: 43 MARKS

MULTIPLE CHOICE

1. Which one of the following substances is a solid at room temperature?

A. copper
B. water
C. hydrogen
D. neon (2)

2. A change in the state of a pure substance is always accompanied by:

A. an increase in temperature.
B. a constant temperature.
C. a decrease in temperature.
D. the breaking of interparticle forces. (2)

3. A graph of the cooling curve of a pure substance is plotted. When is the graph level with the time axis?

A. Never
B. At the melting point only
C. At the boiling point only
D. At both the melting point and the boiling point (2)

4. The temperature of the substance remains constant, the interparticle forces are becoming weaker and the particles are moving apart. What change of phase could this describe?

A. liquid freezing
B. vapour condensing
C. solid melting
D. vapour undergoing deposition (2)

LONG QUESTIONS

5. Explain, in detail, why the graph of a cooling curve is flat when a change of phase takes place. (5)

6. Give an explanation of how diffusion illustrates the fact that the particles of matter are in constant random motion. (4)

7. Substance A has a higher melting point than substance B. Explain why their boiling points differ by comparing the forces between the particles (interparticle forces) of these substances. (4)

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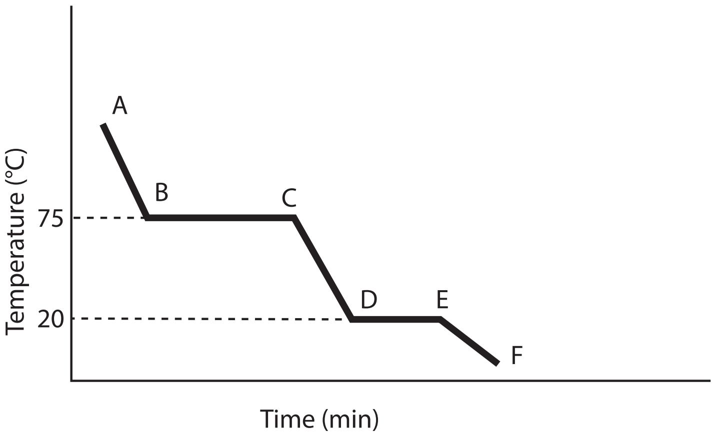
8. Name two factors that will determine the state of a substance at room temperature. (4)

9. A graph showing the cooling curve of substance X is shown below. Refer to this graph and answer the questions that follow.



9.1 What is the boiling point of substance X? Give reasons for your answer. (4)

9.2 What is the melting point of substance X? Give reasons for your answer. (4)

9.3 Between what points is substance X a gas? Give a reason for your answer. (3)

9.4 Between what points is substance X solid? Give a reason for your answer. (3)

9.5 Between what points is substance X liquid? Give a reason for your answer. (4)

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MARKING GUIDELINES

MULTIPLE CHOICE

1. C ✓✓ The particles in a liquid are able to slip and slide over each other, whereas they remain vibrating in their positions in a solid. The interparticle forces in a solid are stronger than they are in a liquid. All the other choices are incorrect for liquids. (2)

2. A ✓✓ When a substance undergoes a change of state, it doesn't alter chemically in any way. The arrangement of the particles within the substance changes and their average kinetic energy but nothing else. (2)

LONG QUESTIONS

3.

PROPERTIES	SOLID	LIQUID	GAS
Strength of intermolecular forces	Very strong✓	Strong✓	Virtually non-existent ✓
Spaces between the particles	Very small✓	Small✓	Extremely large✓
Movement of the particles	Vibration about a fixed point✓	Able to flow over each other✓	Totally free to move✓

(9)

4. The temperature of sulfur remains constant while it is melting because the thermal energy ✓that is being supplied is not used to increase the kinetic energy of the molecules.✓ The energy is used to move the particles further apart ✓ and to weaken the intermolecular forces.✓ (4)

5. Water has a higher boiling point than alcohol because the intermolecular forces between water molecules are stronger than those between alcohol molecules.✓The boiling point is a measure of the energy needed to separate the molecules completely. ✓ It takes more energy to separate the molecules of water ✓ than those of alcohol ✓ hence water has a higher boiling point. (4)

6. The kinetic molecular theory is as follows:
- All matter is made up of particles which are in constant motion.✓
- There are forces between the particles of matter. ✓
- There are spaces between the particles of matter. ✓ (3)

7. When a substance changes from a liquid to a gas:
- The particles become totally free to move. ✓✓
- The forces holding the particles together are broken (overcome). ✓✓
- The spaces between the particles become relatively large. ✓✓ (6)

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WORKSHEETS

CONSOLIDATION EXERCISE

TOTAL: 43 MARKS

MULTIPLE CHOICE

1. A. ✓✓ Copper is a solid because the interparticle forces at room temperature are stronger in copper than in any of the other substances. Water is a liquid, so the forces are weaker. The other two are gases at room temperature so the intermolecular forces are extremely weak. (2)

2. B. ✓✓ The temperature always remains constant during a change in state of a pure substance. It depends on the type of change in state whether interparticle forces are being strengthened (or formed) or being weakened (or overcome). Temperature increases or decreases occur while heating or cooling a solid, liquid or gas, but not during the change of state. (2)

3. D. ✓✓ Whenever there is a change of state, the temperature will remain constant. So the graph will be flat when the gas changes to a liquid and when the liquid changes to a solid, i.e. at the boiling point and at the melting point. (2)

4. C. ✓✓ The change of state described is one that involves heating of the substance, because the energy supplied is bringing about the changes described. The change has to be either solid to liquid or liquid to gas. (2)

LONG QUESTIONS

5. The lines on a cooling curve are flat when a change of state is taking place because there is no change in temperature. ✓The energy that is being removed from the gas or the liquid as it cools ✓ is released by the particles as they move closer together✓ and the forces between the particles become stronger.✓ The kinetic energy of the particles does not change.✓ (5)

6. Diffusion is the term that describes the process of particles of one substance spreading randomly through another substance, usually a liquid or a gas.✓ When a solid is placed in a liquid, the particles of the solid in contact with liquid move away from the solid to the neighbouring liquid.✓ The particles of the liquid are in constant random motion ✓ and as they move they bump into the particles of the solid and gradually spreading them through the entire liquid. ✓ (4)

7. The fact that A has a higher melting point means that the interparticle forces in A are stronger than in B. ✓ For the substances to melt energy has to be provided to overcome the forces✓ and to move the particles apart. ✓It takes more energy for this to happen in A than it does in B. ✓ (4)

8. The two factors that will determine the state of a substance at room temperature are:
- The strength of the interparticle forces between the particles of a substance. ✓✓
- The amount of kinetic energy that the particles of the substance possess at room temperature. ✓ ✓ (4)

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9. **9.1** Boiling point is 75 °C.✓ This is the first instance where the line is flat✓meaning that a change of state is taking place. Since this is a cooling curve, the first change of state that occurs is the change from gas to liquid ✓ which is the same temperature as the boiling point. ✓ (4)

9.2 The melting point is 20 °C. ✓This is the second temperature at which the line is flat.✓This is the second change of state that occurs, so it must be from liquid to solid✓ which is the same temperature as the melting point. ✓ (4)

9.3 Between A and B ✓ the substance is in the process of cooling from the gaseous state ✓and the temperature drops rapidly.✓ (3)

9.4 X is a solid between E and F.✓ X has undergone a change of state from liquid to solid between D and E.✓ Beyond point E it is solid and still cooling,✓ (3)

9.5 X is a liquid between C and D.✓The substance underwent a change of state from gas to liquid between B and C✓ and it only starts to become solid at point E.✓ So between C and D it is liquid and cooling rapidly.✓ (4)

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Topic 3: The Atom: Building Block of All Matter

WORKSHEET

1. Which scientist's model of the atom consisted of a solid indivisible sphere?

A. Thomson

B. Rutherford

C. Bohr

D. Dalton (2)

2. What was the crucial difference between the Thomson and Rutherford models of the atom?

A. The Thomson model consisted of indivisible particles, while Rutherford's model contained sub-atomic particles.

B. The Thomson model contained charges that occupied different parts of the atom, while Rutherford's model contained charges that were lumped together.

C. The Rutherford model contained charges that occupied different parts of the atom, while Thomson's model contained charges that were lumped together.

D. The Rutherford model did not incorporate a nucleus while Thomson's model did. (2)

3. Choose the statement that best completes the sentence. In a neutral atom of any element there are always …

A. equal numbers of protons and neutrons.

B. more protons than neutrons.

C. more electrons than neutrons.

D. equal numbers of protons and electrons. (2)

4. The aluminium ion $^{27}_{13}A\ell^{3+}$ has …

A. 13 protons and 13 electrons.

B. 13 protons and 10 electrons.

C. 13 protons and 16 electrons.

D. 13 protons and 13 neutrons. (2)

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5. The phosphorus ion $^{31}_{15}P^{3-}$ has …

A. 15 protons and 16 neutrons.

B. 15 protons and 15 electrons.

C. 15 protons 12 electrons.

D. 31 protons and 15 neutrons. (2)

LONG QUESTIONS

6. Define:

6.1 atomic number.

6.2 mass number. (2)

(2)

7. Are the following isotopes of the same element?

$^{32}_{16}W$ and $^{34}_{16}X^{2-}$

Give reasons for your answer referring to specific numbers involved. (5)

8. Draw orbital diagrams (energy level diagrams) for the elements Si and O to show the electron arrangement in neutral atoms of these elements. (5)

9. State:

9.1 Pauli's exclusion principle.

9.2 Hund's rule. (2)

(3)

10. Write electron configurations for:

10.1 Ar

10.2 Mg^{2+} (2)

(2)

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CONSOLIDATION EXERCISE

TOTAL: 30 MARKS

MULTIPLE CHOICE

1. Which one of the following statements best describes Rutherford's model of the atom?

A. A solid indivisible sphere.

B. A spongy positive mass in which negative charges are embedded.

C. A positive nucleus with electrons orbiting it like planets orbit the sun.

D. A positive nucleus with electrons moving randomly around it. (2)

2. How many neutrons are there in this atom: $^{40}_{16}K$?

A. 19

B. 21

C. 40

D. 59 (2)

3. Which one of the following statements is correct for this ion: $^{37}_{17}C\ell^{-}$? It contains:

A. more protons than neutrons.

B. more electrons than protons.

C. more protons than electrons.

D. more electrons than neutrons. (2)

4. Which one of the following electron configurations represents an atom in an excited state?

A. $1s^2$

B. $1s^22s^22p^5$

C. $1s^23s^1$

D. $1s^22s^22p^63s^23p^1$ (2)

5. How many different types of orbitals are found in energy level 3?

A. 1

B. 2

C. 3

D. 4 (2)

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LONG QUESTIONS

6. How did the results of Rutherford's alpha particle scattering experiment lead him to propose a new model of the atom? (4)

7. Describe the difference between atomic mass and relative atomic mass. (3)

8. The element potassium has three naturally occurring isotopes with the following abundance:

$^{39}K = 93,26\%$

$^{40}K = 0,2\%$

$^{41}K = 6,57\%$

Calculate the relative atomic mass of potassium. (4)

9. What is meant by an atomic orbital, and how does it differ from an orbit? (4)

10. Naturally occurring neon has three isotopes with the following abundance:

$^{20}Ne = 90,48\%$

$^{X}Ne = 0,233\%$

$^{22}Ne = 9,25\%$

By means of calculation determine the mass number X, if the relative atomic mass of neon is 20,18. (5)

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MARKING GUIDELINES

MULTIPLE CHOICE

1. D✓✓ Rutherford's model had a nucleus and the negative charges moved around that nucleus. (2)

2. C✓✓ Thomson's model was called the plum pudding model because it contained a positive mass in which the negative charges were embedded. Rutherford's model had a nucleus and the negative charges moved around that nucleus. (2)

3. D✓✓ There have to be equal numbers of protons and electrons in neutral atoms because each proton carries a positive charge and each electron carries an equal but negative charge. (2)

4. B✓✓ The ion represented here has 13 protons (its atomic number is 13 – bottom left). In order for the ion to have a charge of +3, it must have lost 3 electrons and so it will have only 10 electrons. (2)

5. A✓✓ The mass number is 31 (top left). This is the sum of the number of protons and neutrons. The atomic number is 15 (bottom left) is the number of protons, so the number of neutrons is 31 – 15 = 16. (2)

LONG QUESTIONS

6. **6.1** Atomic number is the number of protons in the nucleus of all atoms of an element. ✓✓ (2)

6.2 The mass number of the atom (or ion) is the sum of the number of protons and neutrons in its nucleus. (2)

7. Yes they are isotopes of the same element.✓W and X both have 16 protons✓ so they are atoms of the same element. ✓ They differ in that W has 16 neutrons ✓while X has 18 neutrons. ✓ (The fact that one is charged makes no difference.) (5)

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8. One mark for the correct layout of the energy level diagram.✓

silicon					**oxygen**				
3p	1	1		✓					
3s	1l								
2p	1l	1l	1l	✓	2p	1l	1	1	✓
2s	1l				2s	1l			
1s	1l	1l			1s	1l	✓		

(5)

9. **9.1** Pauli's exclusion principle states that only two electrons of opposite spin may occupy the same orbital. ✓✓ (2)

9.2 Hund's rule: When orbitals of the same energy are to be filled ✓each one must be filled singly ✓ before any orbital can have two electrons.✓ (3)

10. **10.1** Electron configuration for Ar:
$1s^2\ 2s^2\ 2p^6\ 2s^2\ 3p^6$ ✓✓ (2)

10.2 Electron configuration for Mg^{2+}:
$1s^2\ 2s^2\ 2p^6$ ✓✓ (2)

This is an ion and has lost 2 electrons, so it only has 10 electrons.

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WORKSHEETS

CONSOLIDATION EXERCISE

TOTAL: 30 MARKS

MULTIPLE CHOICE

1. D ✓✓ It is important to note that in Rutherford's model, the electrons did not occupy fixed positions but were arranged randomly around the nucleus. (2)
2. B ✓✓ The number of neutrons is equal to mass number – atomic number, i.e. 40 – 19 = 21 (2)
3. B ✓✓ The nuclide has a charge of −1, which means that it has gained one electron. It thus has more electrons than protons. (2)
4. C ✓✓ The atom has three electrons. The third electron must be a 2s electron for it to be in the ground state. In this case it is in the 3s orbital, so the atom is in an excited state. (2)
5. C ✓✓ In the third energy level there are s, p and d orbitals. This means that there are three different types of orbitals. (2)

LONG QUESTIONS

6. His observations led him to believe that the atom was mainly empty space,✓ as most alpha particles went straight through the gold foil. ✓ The results also led him to conclude that there was a positive central massive particle ✓(the nucleus), because a number of alpha particles were reflected back from the gold foil.✓ (4)
7. Atomic mass refers to the average mass of all the isotopes of an element, measured in kilograms. ✓ Relative atomic mass is the average of the mass of all the isotopes of the element✓ relative to the mass of a carbon-12 isotope. ✓ (3)
8. In a sample of 100 atoms:

$$\text{Relative atomic mass} = \frac{(39 \times 93,26)\checkmark + (40 \times 0,2)\checkmark + (41 \times 6,57)\checkmark}{100}$$

$$= \frac{3637,14 + 8 + 269,37}{100}$$

$$= 39,15\checkmark$$

(4)

9. An orbit describes the path that an object follows when it is rotating about another object. ✓It is a fixed path and we always know exactly where the object is and how fast it is moving.✓ An atomic orbital is a region around the nucleus of an atom in which there is a high probability (98%) of finding an electron.✓ We don't know exactly where the electron is or how fast it is moving.✓ (4)

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10. Relative atomic mass $= \dfrac{(20 \times 90,48)\checkmark + (X \times 0,233)\checkmark + (22 \times 9,25)\checkmark}{100}$

$$20,18 = \frac{1809,60 + 0,233X + 203,50}{100}$$

$$2018 = 2013,10 + 0,233X \checkmark$$

$$X = 21,03 \checkmark$$

Mass number $= 21\checkmark$

Remember that mass number must be a whole number. (5)

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Topic 4: The Periodic Table

WORKSHEET

MULTIPLE CHOICE

1. Group 1 of the elements in the Periodic Table is known as the:

A. alkaline earth metals.

B. alkali metals.

C. halogens.

D. noble gases. (2)

2. Which one of the following statements is true for the elements in group 2 of the Periodic Table?

A. They all have the same number of electrons.

B. They have completely different chemical properties.

C. They all have the same number of valence electrons.

D. They all have valence electrons in *p* orbitals. (2)

LONG QUESTIONS

3. Consider the elements of period 2 in the Periodic Table.

3.1 What do all these elements have in common? (2)

3.2 Describe and explain the trend in 1st ionisation energy going from left to right across period 2. (5)

4. The questions that follow are about the element fluorine.

4.1 Write down the electron configuration of fluorine. (2)

4.2 How many valence electrons does each atom of fluorine have? (1)

4.3 How many unpaired electrons does each atom of fluorine have? (1)

4.4 Explain why fluorine is such a reactive element. (3)

4.5 How does the reactivity of fluorine compare with that of iodine which is also in group 17? Explain why their reactivities differ. Explain your answer. (4)

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5. Element A and element Z are both in period 2 of the Periodic Table. Element A is in group 2 and element Z is in group 14.

5.1 Write down the electron configurations of elements A and Z. (4)

5.2 How many valence electrons does each element have? (2)

5.3 Classify each element as metal, metalloid or non-metal. (2)

5.4 How do their melting points compare? Give a reason for your answer in terms of trends in the Periodic Table. (3)

6. Two elements X and Q are both in group 15 of the Periodic Table. Element X is in period 2 while Q is in period 3.

6.1 What similarity and what difference is there between the electron arrangements of the two elements? (2)

6.2 Which of the two elements is more reactive? Explain your answer. (4)

6.3 Classify each element as a metal, non-metal or metalloid. (2)

7. **7.1** Define the term 'electron affinity'. (3)

7.2 What is the trend for electron affinity:

7.2.1 across the periods from left to right? Explain your answer. (4)

7.2.2 down the groups from top to bottom? Explain your answer. (4)

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CONSOLIDATION EXERCISE

TOTAL: 43 MARKS

MULTIPLE CHOICE

1. Which group of elements would generally have the lowest first ionization energy?

A. alkali metals

B. noble gases

C. alkaline earth metals

D. halogens (2)

2. Which two particles are formed when an atom is ionised?

A. anion and a proton

B. cation and a proton

C. cation and an electron

D. anion and an electron (2)

LONG QUESTIONS

3. Gallium (Ga) has a first ionisation energy of 579 kJ·mol^{-1}, and calcium has a first ionisation energy of 590 kJ·mol^{-1}.

3.1 According to these values, which of these two elements is the more reactive? Justify your answer. (4)

3.2 These two elements are in the same period. What is the trend for ionisation energies across a period? (2)

3.3 Do these elements fit in with the trend? (1)

4. Give definitions for:

3.4 atomic radius. (2)

3.5 electronegativity. (3)

5. Element Q has 12 protons. Element A is in the period below Q.

5.1 Identify element A. (1)

5.2 Which of these two elements has the greater atomic radius? Justify your answer. (3)

5.3 Write down a word equation for the reaction between element A and chlorine. Use the chemical name for element A in your answer. (3)

5.4 Write down the chemical formula for the substance formed in the reaction in 5.3. (2)

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6. The following questions refer to the noble gases.

6.1 In what group of the Periodic Table are the noble gases found? (1)

6.2 Write down the **general** valence electron configuration for noble gases. (2)

6.3 By referring to their electron configuration, explain why the noble gases are extremely unreactive. (4)

7. Magnesium metal reacts readily with oxygen when it is burned in air.

7.1 Write down a word equation for the reaction of magnesium with oxygen. (3)

7.2 Write down the chemical formula for the substance formed in 7.1. (2)

7.3 Write down the valence electron configuration of magnesium. (2)

7.4 Write down the valence electron configuration of oxygen. (2)

7.5 Write down the symbol for the cation formed when magnesium loses its valence electrons. (1)

7.6 Write down the symbol for the anion formed when oxygen accepts two electrons into its valence shell. (1)

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MARKING GUIDELINES

MULTIPLE CHOICE

1. B✓✓ (2)

2. C✓✓ All the elements in the same group of the Periodic Table have the same number of valence electrons and the same valence electron configuration. (2)

LONG QUESTIONS

3. **3.1** They all have valence electrons in the energy level 2. ✓✓ (2)

3.2
- The ionisation energy increases across a period. ✓
- In going from left to right across a period, the number of protons in the nucleus of atoms of an element increases by 1 for each successive group. ✓
- Thus the number of electrons also increases by 1, but they are all occupying the same energy level, so the distance from the nucleus is virtually the same.✓
- Thus the nuclear attraction on the electrons increases from left to right ✓and more energy is required to remove the valence electron(s).✓ (5)

4. **4.1** $1s^2 2s^2 2p_x^2 2p_y^2 2p_z^1$ ✓✓ OR $1s^2 2s^2 2p^5$ (2)

4.2 7 ✓ (1)

4.3 1 ✓ (1)

4.4 Fluorine is very reactive because it has a small atomic radius, ✓which means that its valence electrons are close the nucleus.✓ It has very high electron affinity, which means that it attracts an electron very strongly.✓ (3)

4.5 Fluorine is more reactive than iodine. ✓ Fluorine has a greater electron affinity than iodine,✓ because electron affinity decreases down a group.✓ So, fluorine attracts electrons more strongly.✓ (4)

5. **5.1** A $1s^2 2s^2$ ✓✓ Z $1s^2 2s^2 2p_x^1 2p_y^1$ ✓✓ (4)

5.2 A 2 ✓ Z 4 ✓ (2)

5.3 A metal ✓ Z non-metal ✓ (2)

5.4 The melting point of Z is higher than that of A.✓The melting of elements in group 2 increases from group 1 to group 14.✓✓ (3)

6. **6.1** They have the same number of valence electrons (5) – similarity ✓ The valence electrons of X are in energy level 2 while those of Q are in energy level 3 – difference.✓ (2)

6.2 Element Q is the more reactive element. ✓It is lower down in the group ✓and ionisation energy deceases from top to bottom. ✓ It takes less energy to remove an electron from element Q therefore Q is more reactive.✓ (4)

6.3 Both elements are non-metals. ✓✓ (2)

7. **7.1** Electron affinity is the amount of energy released ✓when a neutral atom✓ accepts an electron.✓ (3)

7.2 **7.2.1** Electron affinity increases from left to right across a period. ✓The atomic radius decreases ✓from left to right, which means that the atoms become smaller✓and there is greater attraction on electrons. ✓ (4)

7.2.2 Electron affinity decreases from top to bottom in a group.✓ In going down the group, an energy level is added at each period.✓ This means that the atoms are getting bigger ✓and there is less force of attraction on the electrons.✓ (4)

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CONSOLIDATION EXERCISE

TOTAL: 43 MARKS

MULTIPLE CHOICE

1. A ✓✓ The alkali metals all have a single valence electron which requires relatively little energy to remove. (2)

2. C ✓✓ Ionisation energy is supplied to an atom in order to remove a valence electron. Once this electron(s) has been removed, the remaining particle is a positively charged ion, i.e. a cation. (2)

LONG QUESTIONS

3. **3.1** According to the values given, the more reactive element should be gallium.✓ Gallium has a lower ionisation energy ✓ therefore it requires less energy ✓ to remove a valence electron. ✓ (4)

3.2 The trend is that ionisation energy increases from left to right across a period.✓✓ (2)

3.3 They do not. ✓ (1)
Remind learners that a trend is a general way in which a particular property changes but there may be discrepancies which go against the trend.

4. **4.1** Atomic radius is the average distance from the nucleus of an atom to the outermost energy level.✓✓ (2)

4.2 Electronegativity is a measure of the attraction✓ which an atom has for a shared pair of electrons✓ in a bond.✓ (3)

5. **5.1** Calcium ✓
Element Q has 12 protons, so it is magnesium. The element below it is calcium. (1)

5.2 Calcium (element A)✓. It has an extra energy level compared to magnesium,✓ so its valence electrons are further from the nucleus.✓ (3)

5.3 calcium✓ + chlorine✓ → calcium chloride ✓ (3)

5.4 $CaC\ell_2$ ✓✓ (2)

6. **6.1** Group 18 ✓ (1)

6.2 The general valence electron configuration is:
$ns^2\ np^6$ ✓✓
where n is the number of the energy level. (2)

6.3 The noble gases have complete outer energy levels, i.e. they contain eight valence electrons.✓They have no unpaired electrons in their outer shell.✓So, they do not need to gain ✓or lose electrons ✓and thus do not react. (4)

7. **7.1** magnesium✓ + oxygen ✓→ magnesium oxide ✓ (3)

7.2 MgO ✓✓
Magnesium ions have a charge of +2 and oxide ions have a charge of −2, so they combine in a ratio 1:1. (2)

7.3. Valence electron configuration for magnesium is:
$3s^2$ ✓✓ (2)

7.4 Valence electron configuration for oxygen is:
$2s^2 2p_x^2 2p_y^1 2p_z^1$ ✓✓ OR $2s^2 2p^4$ (2)

7.5 Mg^{2+} ✓
When magnesium has lost its valence electrons, it has an excess of two protons over electrons, so its charge is +2. (1)

7.6 O^{2-}✓
When oxygen gains 2 electrons, its valence shell is full and it has an excess of two electrons over protons, so its charge is −2. (1)

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Topic 5: Chemical Bonding

WORKSHEET

MULTIPLE CHOICE

1. In which one of the following is there ionic bonding?

A. HCℓ

B. KF

C. NH_3

D. Pb (2)

2. Covalent bonding is characterised by:

A. the transfer of electrons.

B. the number of valence electrons.

C. the sharing of electrons.

D. delocalised electrons. (2)

LONG QUESTIONS

3. Hydrogen gas and chlorine gas react with each other to produce hydrogen chloride gas.

3.1 Name the type of bonding that occurs in a molecule of hydrogen chloride. (1)

3.2 Draw a Lewis diagram for a molecule of hydrogen chloride. (2)

3.3 Draw a Couper diagram for a molecule of hydrogen chloride. (2)

4. Potassium metal burns in fluorine gas to form potassium fluoride.

4.1 Name the type of bonding that occurs in potassium fluoride. (1)

4.2 Give the chemical symbol for each of the ions formed during this chemical reaction. (2)

4.3 By means of Lewis diagrams show the formation of potassium fluoride. (5)

5. Write down the chemical formula for each of the following:

5.1 aluminium trioxide

5.2 carbon tetrahydride

5.3 sulfur dioxide

5.4 sodium sulfide

5.5 iron(III) phosphate (5)

6. Give the correct chemical name for each of the following:

6.1 SO_3

6.2 K_2CO_3

6.3 $Cr_2(SO_4)_3$

6.4 HNO_3

6.5 HF (5)

7. **7.1** Name the type of bonding that occurs in copper. (1)

7.2 Give an explanation of how electrons become delocalised in copper. (4)

7.3 What electrostatic force is responsible for holding the structure of copper together? (2)

8. Nitrogen gas exists in nature as molecules of N_2.

8.1 What name is given to molecules that consist of two atoms? (1)

8.2 Draw a Lewis diagram for a molecule of nitrogen gas. (2)

8.3 Describe how the bonding between two atoms of nitrogen occurs in the formation of N_2 molecules. (3)

8.4 What is the name given to this type of bond? (1)

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CONSOLIDATION EXERCISE

TOTAL: 44 MARKS

MULTIPLE CHOICE

1. In which one of the following substances are there both covalent bonds and ionic bonds?

A. $(NH_4)_2O$

B. KF

C. H_2O

D. CO_2 (2)

2. Which one of the following substances has delocalised electrons?

A. F_2

B. H_2

C. Ne

D. Mg (2)

LONG QUESTIONS

3. What characterises each of the following bonds? (That is, what makes each of the following bonds different to the others?)

3.1. Ionic bonding (2)

3.2 Metallic bonding (2)

3.3 Covalent bonding (2)

4. All chemical bonds occur because of electrostatic forces of attraction. Describe the type of forces which occur in each of the following bonds.

4.1 Covalent bonds (2)

4.2 Ionic bonds (2)

4.3 Metallic bonds (2)

5. Copy and complete the table below.

Substance	Type of bond	Electrons	Forces between
NaF			
Fe			
H_2O			

(9)

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6. Give the chemical name for each of the following:

6.1 H_3PO_4

6.2 $AgNO_3$

6.3 NO_2 (3)

7. Oxygen occurs in nature as diatomic molecules with the formula O_2.

7.1 How many oxygen atoms are there in each molecule? (1)

7.2 What type of bond occurs between the oxygen atoms? (2)

7.3 Draw a Lewis diagram for a molecule of oxygen. (2)

7.4 Draw a Couper diagram for a molecule of oxygen. (2)

8. Calculate the formula/molecular mass for each of the following substances. In each case, say whether you have calculated the formula mass or the molecular mass of the substance.

8.1 $A\ell(NO_3)_3$ (3)

8.2 $CuCO_3$ (3)

8.3 CF_4 (3)

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MARKING GUIDELINES

MULTIPLE CHOICE

1. B✓✓ This compound is made up of a metal and a non-metal, so there will be ionic bonding. In HCℓ and NH_3 there will be covalent bonding because both elements that combined to give the compounds are non-metals. Pb is a metal and there will be metallic bonding. (2)

2. C✓✓ (2)

LONG QUESTIONS

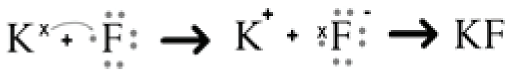
3. **3.1** Covalent bond ✓ (1)

3.2  ✓✓ (2)

3.3 H–Cl ✓✓ (2)

4. **4.1** Ionic bonding ✓ (1)

4.2 The two ions formed are K^+ and F^- ✓ (2)

4.3 

✓ ✓ ✓ ✓ ✓ (5)

5. **5.1** $A\ell_2O_3$ ✓

5.2 CH_4 ✓ (tetra- means four)

5.3 SO_2 ✓

5.4 Na_2S ✓

5.5 $FePO_4$ ✓ [iron(III) means Fe^{3+}] (5)

6. **6.1** sulfur trioxide ✓ (tri- means three)

6.2 potassium carbonate ✓

6.3 chromium(III) sulfate ✓
The sulfate ion has a charge of –2 and there are three of them, making –6. The chromium must balance that with a charge of +6. There are two of them, so the charge on each is +3, hence chromium(III).

6.4 hydrogen nitrate ✓ (nitric acid)

6.5 hydrogen fluoride ✓ (5)

7. 7.1 Metallic bonding ✓ (1)

7.4 Metal atoms have valence orbitals that overlap. The valence electrons in each atom can thus move into the valence orbitals of other atoms. ✓This happens all the time in a random way.✓ So, the valence electrons are not associated with any particular atom✓ but are spread over the entire structure. ✓These are called delocalised electrons. (4)

7.3 The electrostatic force between positive metal ions (cations) ✓and delocalised electrons.✓ (2)

8. 8.1 Molecules containing two atoms are called diatomic molecules.✓ (1)

8.2  ✓✓ (2)

8.3 Each nitrogen atom has three unpaired electrons.✓ These electrons each form a shared pair✓ and thus there are three shared pairs.✓ (3)

8.4 This is called a triple bond.✓ (1)

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CONSOLIDATION EXERCISE

TOTAL: 44 MARKS

MULTIPLE CHOICE

1. A ✓✓ NH_4^+ is made from N and H both of which are non-metals, so they are bonded covalently. The NH_4^+ ion behaves like a metal because it is positive. So, when NH_4^+ combines with O^{2-} it forms ionic bonds.
KF has ionic bonds only and the other two have covalent bonds only. (2)

2. D ✓✓ Mg is the only metal and delocalised electrons are characteristic of the structure of metals. (2)

LONG QUESTIONS

3. **3.1** The transfer of electrons characterises ionic bonds. ✓✓ (2)

3.2 Delocalised electrons characterise metallic bonds. ✓✓ (2)

3.3 Shared electrons characterise covalent bonds. ✓✓ (2)

4. **4.1** In a covalent bond, the electrostatic forces are between nuclei and other atoms' electron clouds. ✓✓ (2)

4.2 In ionic bonding, the electrostatic forces occur between positive and negative ions. ✓✓ (2)

4.3 In metallic bonds, the electrostatic forces are between positive metal ions and delocalised electrons. ✓✓ (2)

5.

SUBSTANCE	TYPE OF BOND	ELECTRONS	FORCES BETWEEN
NaF	ionic✓	transfer✓	cations and anions ✓
Fe	metallic✓	delocalised✓	positive metal ions and delocalised electrons✓
H2O	covalent ✓	shared ✓	nuclei and other atom's electrons ✓

(9)

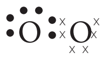
6. **6.1** trihydrogen phosphate ✓ (there are 3 hydrogens – tri-)

6.2 silver nitrate ✓

6.3 nitrogen dioxide ✓ (two oxygens – di-) (3)

7. **7.1** There are two oxygen atoms in the molecule. ✓ (1)

7.2 The bond between oxygen atoms is covalent. ✓✓ (2)

7.3  ✓✓ (2)

7.4 O═O✓✓ (2)

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8. **8.1** $M_r[A\ell(NO_3)_3] = (1 \times 27,0) + (3 \times 14,0) + (9 \times 16,0)$✓
$= 213$ ✓
This is a formula mass (ionic compound)✓
Point out to learners that the number 3 outside the bracket means that everything inside the bracket is multiplied by 3. (3)

8.2 $M_r(CuCO_3) = (1 \times 63,5) + (1 \times 12,0) + (3 \times 16,0)$✓
$= 123,5$ ✓
This is a formula mass (ionic) ✓ (3)

8.3 $M_r(CF_4) = (1 \times 12,0) + (4 \times 19,0)$ ✓
$= 88$ ✓
This a molecular mass (covalent substance) ✓ (3)

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Topics 6 & 7: Transverse Pulses and Transverse Waves

WORKSHEET

MULTIPLE CHOICE

1. A transverse pulse is ...

A. a single disturbance.

B. a single vibration.

C. both A and B.

D. neither A or B. (2)

2. In a transverse pulse the direction of disturbance is always ...

A. in the same direction as the direction of the propagation.

B. in the opposite direction to the direction of propagation.

C. parallel to the direction of propagation.

D. perpendicular to the direction of propagation. (2)

3. The amplitude of the pulse is the ...

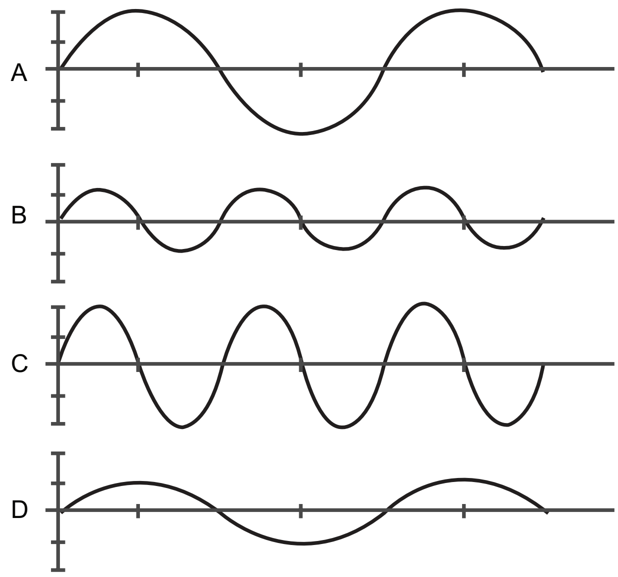
A. maximum displacement of the particles from the rest position.

B. distance travelled by the pulse along the rope (or slinky).

C. distance from the start to the end of the pulse measured along the rope or slinky.

D. displacement between the lowest position of the pulse and its highest point. (2)

Study the diagrams of the four waves shown below. Refer to the diagrams for questions 4 and 5.



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4. Which wave has the greatest amplitude and the greatest frequency?

A

B

C

D (2)

5. Which two waves are in phase with each other?

A A and B

B A and C

C A and D

D B and D (2)

6. Two waves passing through the same medium can destroy each other when they meet up with each other if they have ...

A the same frequency and amplitude.

B the same period and speed.

C the same amplitude, frequency and phase.

D the same amplitude and speed. (2)

7. The vibrations of a transverse wave move ...

A in the same direction as the wave travels.

B at right angles to the direction of wave travel.

C above and below the moving wave.

D opposite to the direction of wave travel. (2)

8. A wave of wavelength 3 m is generated by a vibration with a frequency of 20 Hz. What is the period and the speed of this wave?

	PERIOD (S)	SPEED ($m \cdot s^{-1}$)
A	$\frac{1}{20}$	$\frac{3}{20}$
B	$\frac{1}{20}$	$\frac{20}{3}$
C	20	$\frac{20}{3}$
D	20	$\frac{3}{20}$

(2)

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9. When the frequency of vibration of a wave increases, ...

A. the period and the wavelength both increase.

B. the period and the wavelength both decrease.

C. the period increases and the wavelength decreases.

D. the period decreases and the wavelength increases. (2)

10. Water waves with a wavelength of 8 m travel at a speed of 12 $m \cdot s^{-1}$.
How many waves pass a point in one second?

A. 0,67

B. 1,5

C. 20

D. 96 (2)

LONG QUESTIONS

11. A pulse with a length of 4 cm and an amplitude of 2 cm is generated in a rope by jerking the free end of the rope from right to left. Draw a diagram of the pulse as it travels along the rope to a fixed end. Label the following:

11.1 the direction of propagation of the pulse. (2)

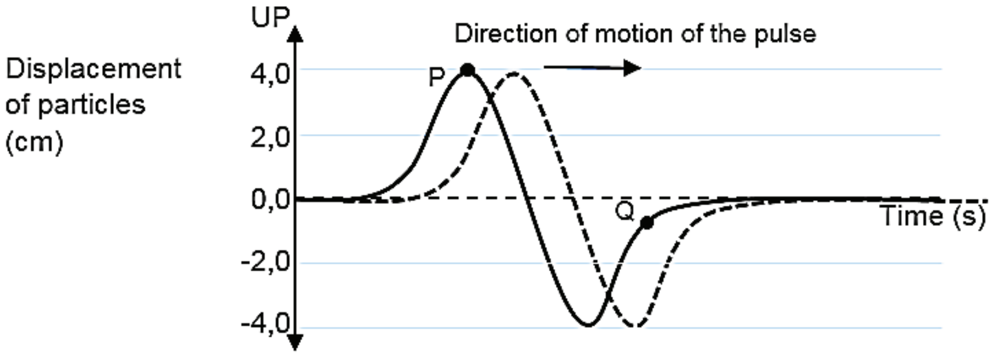
11.2 the rest position of the particles of the rope. (2)

11.3 the amplitude of the pulse and its magnitude. (2)

11.4 the direction of disturbance. (2)

11.5 the pulse length and its magnitude. (2)

12. Study the diagram of a pulse in a rope (shown below).



In 0,1 s the pulse shown with a solid line moves forward to the pulse shown by the dotted line. Copy the diagram into your workbook. Determine the following and place the answers on the copy of the diagram.

12.1 The amplitude (2)

12.2 The direction of the disturbance (2)

12.3 The direction in which particle P is moving (draw an arrow on P to show this) (2)

12.4 The position of particle P in the next 0,1 s (2)

12.5 The position of particle Q in the next 0,1 s (2)

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13. Two pulses A and B move along a rope towards each other.

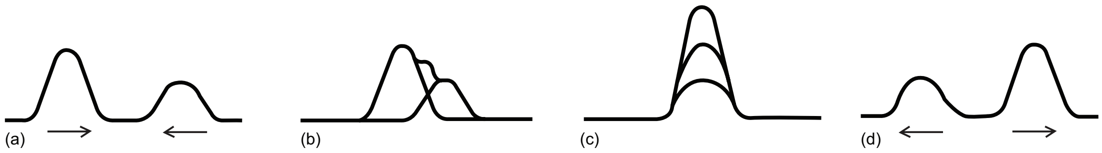
13.1 Name the phenomenon which occurs when the pulses meet each other. (1)

13.2 State the principle of superposition. (2)

13.3 Draw a labelled sketch of pulse A meeting up with pulse B so that they form a larger pulse. What is this phenomenon called? (4)

13.4 Is it ever possible for the rope to remain absolutely straight (in its rest position) while two pulses are passing through it? Explain briefly. (3)

14. The sequence of diagrams which follow show two pulses moving along a rope at various times.

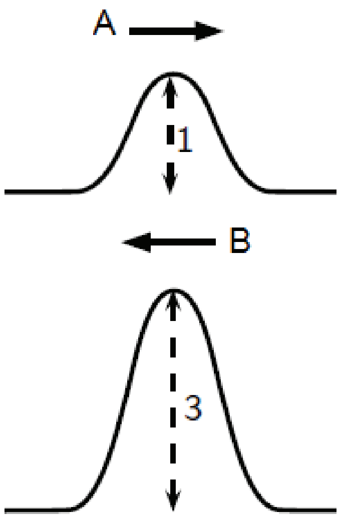


14.1 Name the phenomenon which occurs when these two pulses meet up with each. (2)

14.2 Name and state the principle which is used to calculate the amplitude of the resulting pulse in (b) and (c). (3)

14.3 Explain what has happened in diagram (d), and give a reason why this happens. (3)

15. Two pulses A and B travelling in opposite directions through the same medium (as shown in the diagrams below), meet each.



15.1 Explain what the term "the pulses are in phase with each other" means. (2)

15.2 Draw the resultant pulse. (2)

15.3 Is this an example of constructive or destructive interference? (2)

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16. Draw a labelled diagram of a transverse wave showing the following:

16.1 the wavelength (1)

16.2 the amplitude (1)

16.3 the rest position of the particles of the medium (1)

13.4 the direction of propagation of the wave (1)

13.5 the direction of disturbance of the particles (1)

13.6 a crest (1)

13.7 a trough (1)

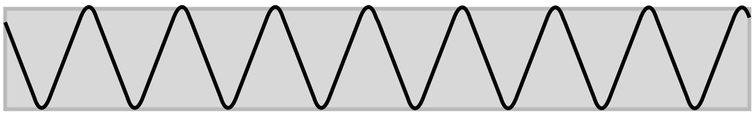
17. Draw a labelled diagram to show destructive interference of two transverse waves A and B. The amplitude of wave A is twice that of wave B. (3)

18. A boat out at sea bobs up and down 6 times a minute. The wavelength of the waves is 4 m.

18.1 Calculate the frequency of the vibration of the boat on the water (in Hz). (3)

18.2 Calculate the speed of the waves. (3)

19. A cork bobs up and down in a pond as the 9 crests of a wave pass beneath it. The waves travel a distance of 20 m in the 50 s it takes for the crests to pass beneath the cork.



19.1 How many complete waves pass beneath the cork? Briefly explain how you obtain your answer. (2)

19.2 Calculate the frequency of the waves. (3)

19.3 Calculate the wavelength of the waves. (5)

CONSOLIDATION EXERCISE

TOTAL: 62 MARKS

MULTIPLE CHOICE

1. The amplitude of a transverse pulse is the …

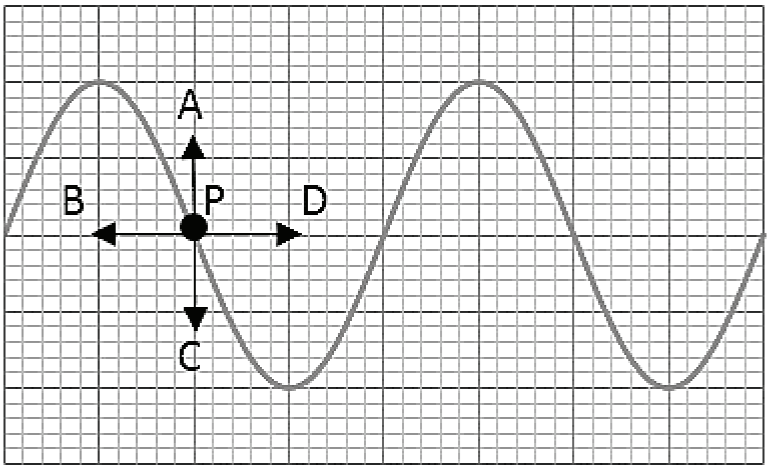
A. maximum distance of the disturbance from its rest position.

B. maximum distance from the position of a trough to the position of a crest.

C. maximum distance travelled from the beginning of the pulse to its end.

D. time taken for a pulse to pass a point. (2)

2. The diagram below shows a transverse wave moving from left to right in a rope. In which direction is point P moving at this moment?



(2)

3. A transverse wave of wavelength 4 cm travels at 0,2 $m \cdot s^{-1}$. What is the frequency of this wave?

A. 0,05 Hz

B. 0,8 Hz

C. 5 Hz

D. 20 Hz (2)

4. 10 crests pass a point in 3 s. The wavelength of the waves is 20 cm. What is the frequency and the velocity of the waves?

	FREQUENCY (Hz)	VELOCITY ($m \cdot s^{-1}$)
A	3,00	0,60
B	3,33	0,66
C	3,00	6,00
D	3,33	6,66

(2)

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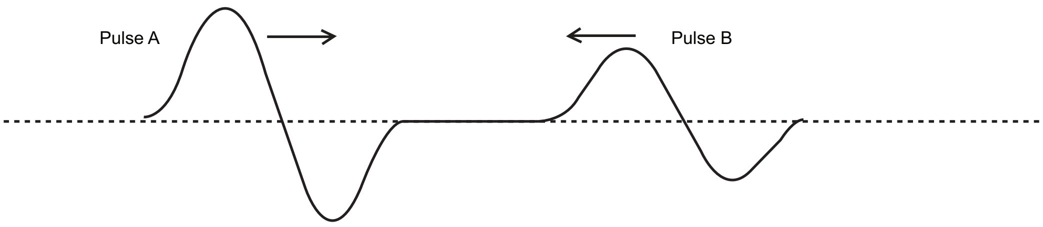
5. Pulse A meets Pulse B as they travel in opposite directions along a slinky. After they have crossed over each other, what happens to Pulse A and Pulse B?



A. Pulse A and Pulse B are destroyed by each other; they stop moving.

B. Pulse A and Pulse B continue to move in the same direction as they were moving before they met up with each other.

C. Pulse A and Pulse B reflect; they move back down the slinky in opposite directions.

D. Pulse A and Pulse B continue to interfere with one another. (2)

6. The velocity of a pulse in a rope or a slinky depends on

A. its amplitude.

B. its energy.

C. the tension in the rope or slinky.

D. the pulse length. (2)

LONG QUESTIONS

7. Transverse waves, with a wavelength of 0,40 m, travel along a rope at 0,25 $m{\cdot}s^{-1}$. The amplitude of the waves is 0,30 m.

7.1 Explain what is a transverse wave. (2)

7.2 Draw a labelled diagram showing two wavelengths of the wave to illustrate your answer. Label the directions of disturbance and propagation, the amplitude and the wavelength. (4)

7.3 Calculate the frequency of the waves. (3)

7.4 Calculate the period of the waves. (3)

7.5 When the frequency of the waves is doubled, how are the following quantities affected? Briefly justify each answer.

7.5.1 The period of the wave (2)

7.5.2 The speed of the waves (2)

7.5.3 The wavelength of the wave (2)

7.5.4 The amplitude of the wave (2)

8. A transverse wave travels 5 m in 2 s. Its wavelength is 3 m.

8.1 Calculate the velocity of the wave. (3)

8.2 Calculate the frequency of the wave. (3)

8.3 Calculate the period of the wave (2)

9. Two water waves A and B of the same wavelength interfere with one another as they move past one another in opposite directions. Wave A has an amplitude of 20 cm; wave B has an amplitude of 10 cm.

At 1,8 s waves A and B interfere constructively with one another.

9.1 State t*he principle of superposition*. (2)

9.2 Draw a labelled diagram to show the constructive interference of waves A and B, and the resultant wave which is formed when they interfere with each other. Label wave A and B, and the resultant wave. (4)

9.3 Explain how these two waves A and B could be made to interfere destructively with one another. (2)

9.4 Draw a labelled diagram to show the destructive interference of waves A and B, and the resultant wave which is formed when they interfere with each other. Label wave A and B, and the resultant wave. (4)

10. When a point source generates water waves in a ripple tank, circular ripples move away from the source.

10.1 Explain why the pattern of ripples is circular. (3)

10.2 The frequency of the point source is 50 Hz and the speed of the water waves is 20 $m \cdot s^{-1}$.

10.2.1 Calculate the wavelength of the waves. (3)

10.2.2 The amplitude of the vibrations is doubled.

a. How does this affect the frequency of the vibration? (1)

b. How does this affect the speed of the ripples through the water? (1)

c. Briefly explain your answers to questions (a) and (b). (2)

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MARKING GUIDELINES

MULTIPLE CHOICE

1. C✓✓ A pulse is a single vibration or a single disturbance or a single oscillation. (2)

2. D✓✓ A transverse pulse has the direction of disturbance at right angles (perpendicular) to the direction of propagation. (2)

3. A✓✓ The amplitude of a pulse is the maximum displacement of the particles from their rest position (the maximum height of the rope (slinky) above the rest position). (2)

4. C✓✓ The displacement from rest position is greatest (greatest amplitude). The number of waves per unit time is greatest (greatest frequency). (2)

5. C✓✓ They both have the same frequency so the particles of the waves move in the same directions at the same time. (2)

6. A✓✓ For the resultant wave to have no amplitude when two waves meet up with each other (interfere with each other), the two waves must have the same amplitude and they must be exactly out of phase with each other. Therefore, they must have the same frequency and they must be exactly out of phase with each other. Options B and D refer to the speed of the wave – it will be constant because the waves are moving through the same medium. Option B would have been a possibility if it had specified that the amplitudes were the same. (2)

7. B✓✓ Transverse waves are defined as those in which the vibrations (particles of the medium) move at right angles to the direction of wave travel. (2)

8. A✓✓

$$T = \frac{1}{f} = \frac{1}{20}$$

$$v = f\lambda = \frac{1}{20} \times 3 = \frac{3}{20}$$

(2)

9. B✓✓ $T = \frac{1}{f}$ If frequency increases, period decreases.

$v = f\lambda$ Velocity (v) remains constant. If f increases, λ decreases. (2)

10. B✓✓ The number of waves passing a point in one second is equal to the frequency of the wave (f).

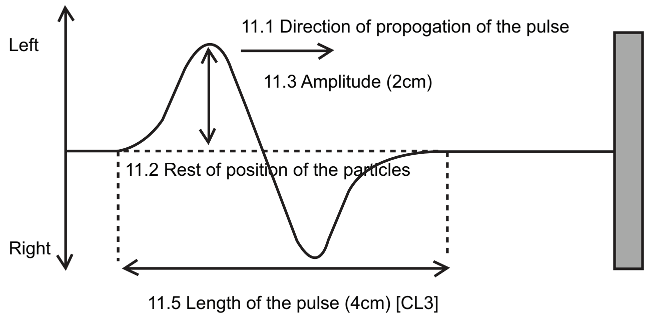
$$v = f\lambda$$

$$f = \frac{v}{\lambda} = \frac{12}{8} = 1{,}5\ \text{Hz}$$

(2)

LONG QUESTIONS

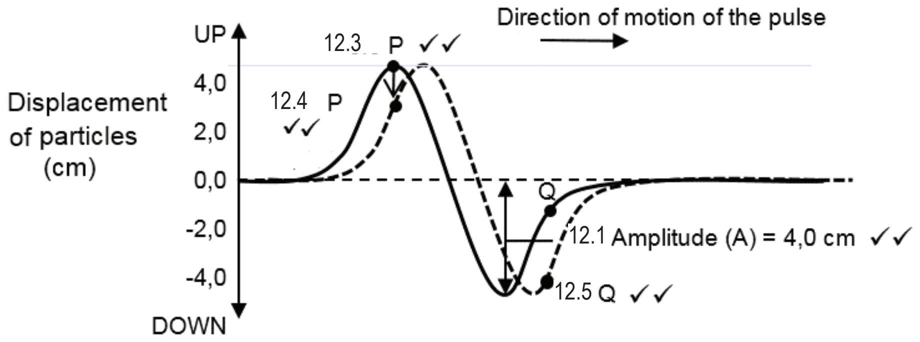
11.



(2)

11.4 Direction of the disturbance is right then left ✓✓
NB: The directions shown on the vertical axis (left and right) must coincide with the shape of the pulse. If they are labelled the other way around the pulse should be rotated by 180° around the x-axis.

12.

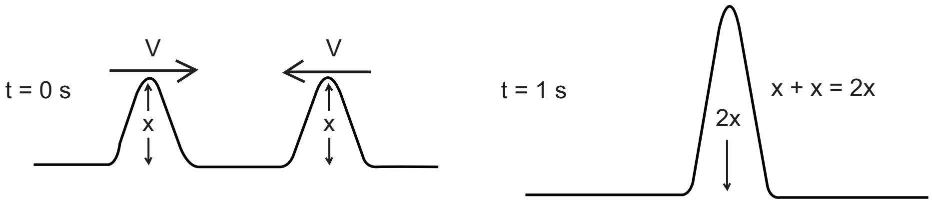


12.2 Direction of disturbance is down and then up ✓along the y-axis. ✓ (10)

13. **13.1** Interference ✓ (1)

13.2 When two pulses occupy the same space at the same time the displacement of the particles of the medium is found by adding the displacement of the two disturbances. ✓✓ (2)

13.3



(4)

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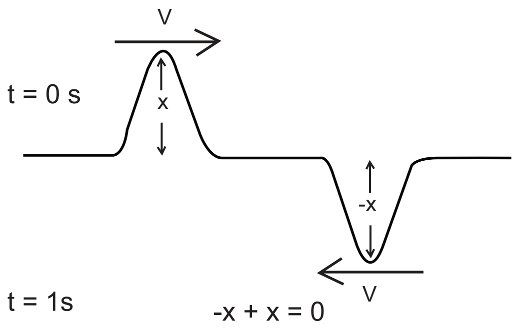
13.4 Yes. When the two pulses are (exactly) out of phase with one another ✓ and they have the same amplitudes ✓ and the same pulse lengths ✓ they can cancel out any movement of the rope for a very short time (an instant) when they interfere. (Diagram is optional).



(3)

14. 14.1 Constructive ✓interference. ✓ (2)

14.2 The principle of superposition. ✓ The amplitude of the resultant pulse is the sum of the amplitudes of the two pulses. ✓✓ (3)

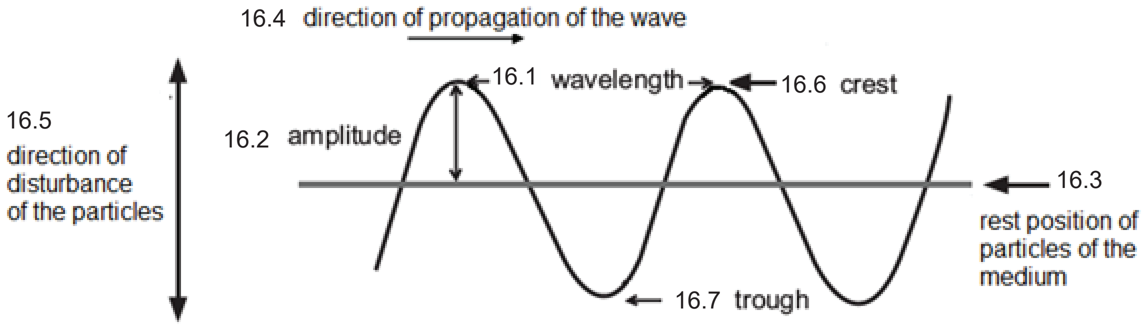
14.3 The pulses have crossed over each other✓; they continue to move along the rope with the same amplitude ✓that they each had before they interfered with each other. ✓ (3)

15. 15.1 The particles of the pulses move in the same direction✓ at the same time (simultaneously) while the pulse moves through the medium.✓ (2)

15.2 Amplitude = algebraic sum of the amplitudes (2)

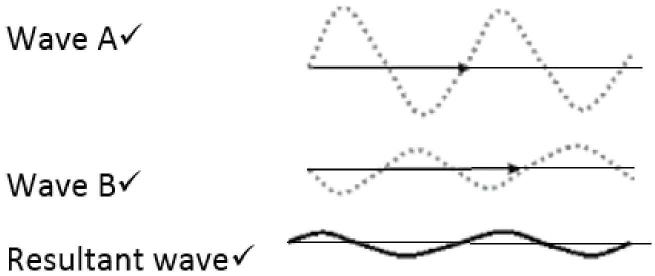
15.3 Constructive ✓interference.✓ (2)

16.



(7)

17.



(3)

18. **18.1** Frequency $= \frac{\text{Number of vibrations}}{\text{Time}}$ ✓

$= \frac{6}{60}$ ✓

$= 0{,}1$ Hz ✓ (3)

18.2 $v = f\lambda$✓

$= 0{,}1 \times 4$✓

$= 0{,}4\ \text{m·s}^{-1}$✓

(3)

19. **19.1** 8 waves ✓

Count the first crest as zero. Then there are 8 complete waves from crests 0 to 9. ✓ (2)

19.2 Frequency $= \frac{\text{Number of vibrations}}{\text{Time}}$ ✓

$= \frac{8}{50}$ ✓

$= 0{,}16$ Hz ✓ (3)

19.3 $v = \frac{\text{displacement}}{\text{time}}$ ✓

$= \frac{20}{50}$ ✓

$= 0{,}4\ \text{m·s}^{-1}$

$v = f\lambda$✓

$0{,}4 = 0{,}16 \times \lambda$✓ (5)

$\lambda = 2{,}5$ m✓

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CONSOLIDATION EXERCISE

TOTAL: 62 MARKS

MULTIPLE CHOICE

1. A ✓✓ The amplitude of a pulse (or wave) is the maximum displacement from the rest position. (2)

2. A ✓✓ The particles move at right angles to the direction of propagation of a transverse wave (or pulse). The only possible answers are therefore A and C. However, in another moment the pulse would have moved towards the right, so particle P would have moved up in the direction of A. (2)

3. C ✓✓ $v = f\lambda$ (Use the wave equation)

$0,2 \times f(0,04)$ (Convert cm to m)

$f = \dfrac{0,2}{0,04}$ (Calculate the value of f)

$= 5 \text{ Hz}$ (2)

4. A ✓✓ 10 crests pass in 3 s therefore 9 complete waves pass the point in 3 s.
The frequency is the number of waves that pass a point in one second therefore f = (number of waves)/time= 9/3=3 Hz
Now apply the wave equation $v = f\lambda$
$= 3 \times 0,2$ (Convert to cm to m)
$= 0,60 \text{ m·s}^{-1}$ (2)

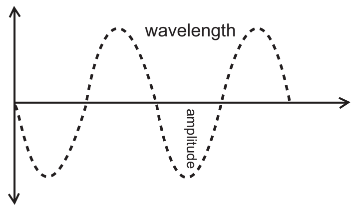
5. B ✓✓ When Pulse A meets Pulse B the two pulses interfere with each other. Thereafter they continue moving in exactly the same way as they did before they met up – they travel in the same directions as before with the same amplitudes as before. (2)

6. C✓✓ The velocity of a pulse (or a wave) in a rope or slinky (or in any medium) depends on the properties of the medium e.g. the tension of the rope or slinky, or its weight (density) etc. (2)

LONG QUESTIONS

7. **7.1** A regular series of disturbances✓ which move at right angles to the direction of propagation of the wave. ✓ (2)

7.2



(4)

7.3 $v = f\lambda$ ✓ Choose the appropriate formula.

$0,2 \times f(0,04)$ ✓ Substitute the values.

$f = \frac{0,2}{0,4} = 0,5\text{ Hz}$ ✓ Calculate the answer. Include the SI units. (3)

7.4 $T = \frac{1}{f}$ ✓ Choose the appropriate formula.

$= \frac{1}{0,5}$ ✓ Substitute the value of *f* from 1.3 above (c.o.e)

= 2 s ✓ Calculate the answer. Include the SI units. (3)

7.5 **7.5.1** Since $T = \frac{1}{f}$ when the frequency is doubled, the period is halved. ✓ Period decreases. ✓ (2)

7.5.2 The speed of the wave depends upon the characteristics of the rope. ✓ Since the wave travels along the same rope, the speed of the wave does not change. ✓ (2)

7.5.3 The relationship between frequency and wavelength is $v = f\lambda$ ✓The speed remains constant therefore if the frequency is doubled the wavelength is halved.✓ (2)

7.5.4 The amplitude remains the same (is unchanged) ✓ because it only depends on the amount of energy given to the waves, and not to the frequency of the vibrations.✓ (2)

8. **8.1** $v = \frac{\text{displacement}}{\text{time}}$ ✓ Choose the appropriate formula.

$= \frac{5}{2}$ ✓ Substitute the values.

= 2,5 $m{\cdot}s^{-1}$✓ Calculate the answer. Include the SI units. (3)

8.2 $v = f\lambda$ ✓ Choose the appropriate formula.

$2,5 = f \times 3$ ✓ Substitute the values.

$f = \frac{2,5}{3} = 0,83\text{ Hz}$ ✓ Calculate the answer. Include the SI units. (3)

8.3 $T = \frac{1}{f}$ ✓ Choose the appropriate formula.

$= \frac{1}{0,8333333}$

= 1,2 s✓ Calculate the answer. Include the SI units. (2)

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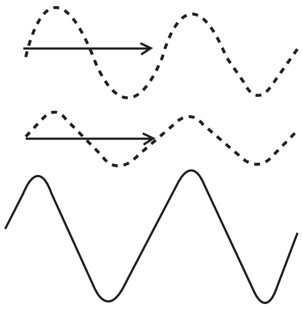
9. **9.1** When two pulses occupy the same space at the same time✓ the displacement of the particles of the medium is found by adding the displacement of the two disturbances.✓ (2)

Wave A: Amplitude 20 cm

Wave B: Amplitude 10 cm

Resultant wave:

Amplitude 30 cm✓✓



9.2 ✓ for both waves A double the amplitude of B

✓ resultant wave in phase with original two waves. (4)

9.3 Wave A and B must be 180° (exactly) out of phase with one another✓ to be able to interfere destructively with each other. Start Wave B's vibrations half a cycle later than wave A's vibrations. ✓ (2)

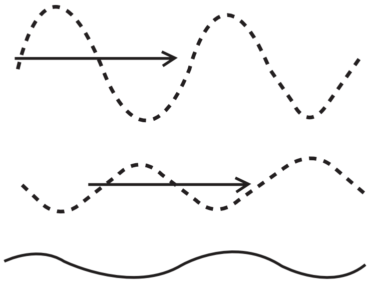
9.4

Wave A: Amplitude 20 cm

Wave B: Amplitude 10 cm

Resultant wave:

Amplitude 10 cm✓



✓ Wave A twice amplitude of wave B

✓ 2 waves out of phase

✓ transverse wave (4)

10. **10.1** The disturbance travels from the point source at the same speed (velocity) in all directions. ✓ In one second it has travelled the same distance from the point. ✓ This makes the location of the crest of the wave to be on the perimeter of a circle. ✓

(3)

10.2.1	$v = f\lambda$ ✓	Choose the appropriate equation.	
	$20 = 50 \times \lambda$ ✓	Substitute the values.	
	$\lambda = \frac{20}{50} = 0{,}4\text{ m}$ ✓	Calculate the answer. Include the SI units.	(3)

10.2.2 a. No effect (Frequency is not changed; remains the same) ✓ (1)

b. No effect (Speed is not changed; remains the same) ✓ (1)

c. The amplitude of a wave depends on the energy of the vibrations, not on the number of vibrations per second (or on the frequency). ✓

The speed of the wave depends on the characteristics of the medium (water in this case). The medium has remained the same, (it is the same water at the same temperature and of the same depth) therefore there is no change in the speed of the waves. ✓ (2)

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Topics 8 & 9: Longitudinal Waves and Sound

WORKSHEET

MULTIPLE CHOICE

1. What kind of wave is a sound wave?

A. a transverse wave.

B. a latitudinal wave.

C. a longitudinal wave.

D. an electromagnetic wave. (2)

2. A louder sound wave has …

A. a greater frequency.

B. more energy.

C. a longer amplitude.

D. a longer period. (2)

3. An ultrasound wave has frequency …

A. greater than 20 000 Hz.

B. lower than 20 000 Hz.

C. lower than 20 Hz.

D. between 20 Hz and 20 000 Hz. (2)

4. The pitch of a sound is related to its …

A. wavelength.

B. speed.

C. amplitude.

D. frequency. (2)

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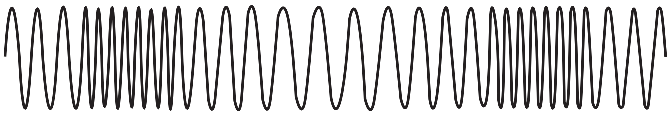
LONG QUESTIONS

5. The diagram below shows a longitudinal wave passing from left to right through a slinky.



Copy the diagram and label the following on the copy of the diagram:

5.1 The wavelength (1)

5.2 A rarefaction (1)

5.3 A compression (1)

5.4 The direction of disturbance (1)

5.5 The direction of wave travel (1)

6. State two differences between longitudinal waves and transverse waves. (2)

7. A longitudinal wave passes down a slinky. It has a wavelength of 0,5 m and a frequency of 0,4 Hz. Calculate:

7.1 the period of the wave. (3)

7.2 the speed of the wave. (3)

8. A longitudinal wave is generated by buzzer that vibrates with a frequency of 600 Hz. It travels through a metal bar with a wavelength of 9 m. When the wave meets the air, it is able to travel through the air with a wavelength of 0,55 m.

8.1 Calculate the speed of the wave in the metal bar. (3)

8.2 Calculate the speed of the wave in the air. (3)

8.3 Explain why the frequency remains constant. (2)

9. A longitudinal wave travels at 330 $m \cdot s^{-1}$ through air, and at 1 200 $m \cdot s^{-1}$ through wood. The vibration which produces the wave has a period of 5 s. Calculate ...

9.1 its frequency. (3)

9.2 its wavelength in air. (4)

9.3 its wavelength in wood. (3)

10. A sound wave travels through water at a speed of 1 500 $m \cdot s^{-1}$. A ship sends a signal with a frequency of 50 000 Hz to the seabed below, and receives the echo 4 s later.

10.1 Calculate the wavelength of the sound wave. (4)

10.2 Calculate the depth of the object from which the sound wave reflected. (4)

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11. Bats navigate by sending out ultrasounds that reflect off their prey (mosquitoes). Their brains process the result telling them the exact location of the insect, and they swoop in to snack on it.

11.1 Explain what ultrasound is. (2)

11.2 A bat receives an echo of ultrasound 1,5 s after it is emitted. The speed of sound in air is 345 $m{\cdot}s^{-1}$. Calculate the distance of the mosquito from the bat. (4)

11.3 The wavelength of the sound wave is 15 mm. Calculate its frequency. (3)

12. Middle C when played on a piano has a frequency of 256 Hz. A note one octave higher has double the frequency, and a note one octave lower has half the frequency. The speed of sound in air is 345 $m{\cdot}s^{-1}$.

12.1 Calculate the wavelength of the note which represents Middle C on a piano. (4)

12.2 How many octaves, higher or lower than Middle C, is a note with a frequency of $4 \times$ Middle C? (2)

12.3 Deduce the wavelength of this note (described in 12.2). (4)

12.4 What happens to the following qualities of the note when it is played on the piano with the same amplitude but one octave lower? Explain briefly.

12.4.1 The loudness (2)

12.4.2 The pitch (2)

13. A ship receives the echo from a signal sent to a submarine 3,5 s after it is transmitted. The speed of sound in water is 1 450 $m{\cdot}s^{-1}$. The wavelength of the sound wave is 2 cm.

13.1 Calculate the distance of the submarine from the ship. (4)

13.2 Calculate the frequency of the sound. (4)

13.3 How must the technician adjust the transmitter to increase the loudness of the sound? Explain briefly. (2)

13.3 How does an adjustment (as in 13.3) affect the frequency of the sound? Explain briefly. (2)

14. Ultrasound is used to monitor abnormalities of the vascular system which could cause heart disease.

14.1 Briefly explain how ultrasound waves are used to produce an image of the arteries and veins (the vascular system). (4)

14.2 Give three advantages of using ultrasound rather than X-rays to monitor heart disease. (3)

15. Ultrasound is used by ships to map the depth of the oceans, for defence, and to locate shoals of fish.

15.1 Why is the sound wave which is used for these purposes "an ultrasound wave"? (Why don't we just use ordinary sound waves for these purposes?) (4)

15.2 What words does SONAR stand for? (1)

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CONSOLIDATION EXERCISE

TOTAL: 32 MARKS

MULTIPLE CHOICE

1. While the wave moves forward, the vibrations that cause longitudinal waves always move ….

A. up and down.

B. left and right.

C. forward and backwards.

D. in circles. (2)

2. The wavelength of a sound wave is measured from …

A. the middle of one compression to the middle of the next successive compression.

B. the rest position of the particles to the maximum displacement for the rest position.

C. one point to the next point which is exactly out of phase with the first point.

D. one trough to one crest of the wave. (2)

3. The speed of sound in air is 330 $m \cdot s^{-1}$. If the frequency of sound is doubled,

A. the speed of sound is doubled.

B. the speed of sound is halved.

C. the wavelength of sound is doubled.

D. the wavelength of sound is halved. (2)

LONG QUESTIONS

4. Bats use echolocation to find the location and size of their prey (insects such as mosquitoes). A mosquito has a wing width of 1 cm. The speed of sound in air is 340 $m \cdot s^{-1}$.

4.1 Give another term for the word "echolocation". (1)

4.2 The wavelength of the sound wave must be less than the width of the insect's wings in order for the bat to receive a loud echo from its prey. Calculate the minimum frequency of sound which the bat can use to identify a mosquito. (4)

4.3 Explain why the sound that bats emit to detect their prey is ultrasonic. (2)

4.4 How long in milliseconds (ms) does it take for the bat to receive an echo from a mosquito that is 1 m away from it? (4)

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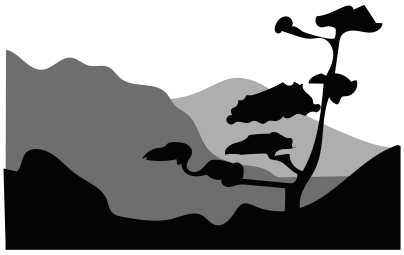
5. A sound wave travels along a railway line at a speed of 5 400 m·s^{-1}. Sound travels through air at 340 m·s^{-1}. The train is 12 km away from a man, who puts his ear to the line.

5.1 How long does it take for the man to hear the sound of the train in the line? (4)

5.2 What minimum delay is there (after he hears the train in the line) before he hears the sound of the train through the air? (4)

6. A mountaineer standing 475 m in front of a vertical mountain face, claps his hands loudly so that the echo bounces off the mountain face, and the next mountain face which is immediately behind it. The first echo is heard after 3 s, and the second echo arrives 6,5 s later.



6.1 Calculate the speed of sound. (3)

6.2 How far apart are the two vertical mountain faces? (4)

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MARKING GUIDELINES

MULTIPLE CHOICE

1. C✓✓ A sound wave is a longitudinal wave. (2)

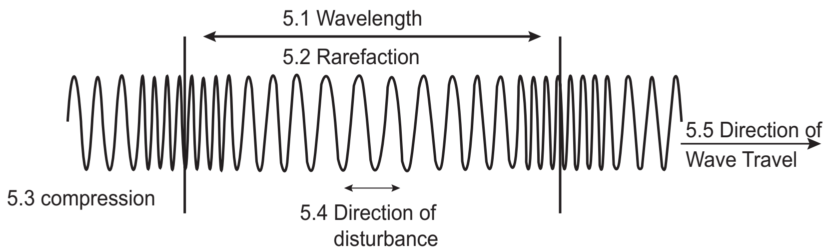
2. B✓✓ Loudness is related to the amplitude of the wave.
Amplitude is related to the energy of the vibration therefore a louder sound has more energy. (2)

3. A✓✓ Ultrasound is defined as a sound wave with a frequency greater than that of human hearing (which is at 20 000 Hz). (2)

4. D✓✓ (2)

LONG QUESTIONS

5.



(5)

6.1 The direction of disturbance in a longitudinal wave is parallel to the direction of wave travel, ✓ but it is perpendicular (at right angles) to the direction of wave travel for a transverse wave. ✓ (2)

6.2 Longitudinal waves need a material medium through which to travel; ✓ transverse waves can propagate through a vacuum. ✓ (2)

7.1	$T = \frac{1}{f}$ ✓	Choose the appropriate formula.	
	$= \frac{1}{0,4}$ ✓	Substitute the value.	
	$= 2,5\text{ s}$ ✓	Calculate the answer. Insert the SI units.	(3)
7.2	$v = f\lambda$ ✓	Choose the appropriate formula.	
	$= 0,4 \times 0,5$ ✓	Substitute the values.	
	$= 0,20\ \text{m·s}^{-1}$ ✓	Calculate the answer. Insert the SI units.	(3)
8.1	$v = f\lambda$ ✓	Choose the appropriate formula.	
	$= 600 \times 9$ ✓	Substitute the values.	
	$= 1\,500\ \text{m·s}^{-1}$ ✓	Calculate the answer. Insert the SI units.	(3)
8.2	$v = f\lambda$ ✓	Choose the appropriate formula.	
	$= 600 \times 0,55$ ✓	Substitute the values.	
	$= 0,330\ \text{m·s}^{-1}$ ✓	Calculate the answer. Insert the SI units.	(3)

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8.3 The frequency remains constant because the longitudinal wave is generated by a source which vibrates at that fixed frequency. ✓✓ (2)

9.1	$f = \frac{1}{T}$ ✓	Choose the appropriate formula.
	$= 1/5$ ✓	Substitute the value.
	$= 0{,}2$ s ✓	Calculate the answer. Insert the SI units. (3)
9.2	$v = f\lambda$ ✓	Choose the appropriate formula.
	$330 = 0{,}2 \times \lambda$ ✓	Substitute the values.
	$\lambda = \frac{330}{0{,}2}$ ✓	Change the subject of the formula.
	$= 1\,650$ m ✓	Calculate the answer. Insert the SI units. (4)
9.3	$v = f\lambda$ ✓	Choose the appropriate formula.
	$1\,200 = 0{,}2 \times \lambda$ ✓	Substitute the values.
	$\lambda = \frac{1\,200}{0{,}2}$ ✓	Change the subject of the formula.
	$= 6\,000$ m ✓	Calculate the answer. Insert the SI units. (3)
10.1	$v = f\lambda$ ✓	Choose the appropriate formula.
	$1\,500 = 50\,000 \times \lambda$ ✓	Substitute the values.
	$\lambda = \frac{1\,500}{50\,000}$ ✓	Change the subject of the formula.
	$= 0{,}03$ m (3cm) ✓	Calculate the answer. Insert the SI units. (4)
10.2	$v = \frac{\text{total distance}}{\text{time}}$ ✓	Choose the appropriate formula.
	$1\,500 = \frac{\text{total distance}}{4}$ ✓	Substitute the values.
	Total distance = 1 500 × 4	Change the subject of the formula.
	= 6 000 ✓ m	Calculate the answer. Ignore SI units.
	Distance of object = ½ × 6 000	The echo travelled 2 × the distance.
	= 3 000 m ✓	Calculate the answer. Insert the SI units (4)

11.1 Ultrasound is a sound wave with a frequency greater than 20 000 Hz. ✓✓ (2)

11.2	$v = \frac{\text{total distance}}{\text{time}}$ ✓	Choose the appropriate formula.
	$345 = \frac{\text{total distance}}{1{,}5}$ ✓	Substitute the values.
	Total distance = 345 × 1,5	Change the subject of the formula.
	= 517,5 ✓ m	Calculate the answer. Ignore SI units.
	Distance of object = ½ × 517.5	The echo travelled 2 × the distance.
	= 258,75 m ✓	Calculate the answer. Insert the SI units (4)

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WORKSHEETS

11.3	$v = f\lambda$ ✓	Choose the appropriate formula.	
	$345 = f \times 0{,}015$✓	Substitute the values.	
		Convert mm to m.	
	$f = \dfrac{345}{0{,}015}$	Change the subject of the formula.	
	= 23 000 Hz✓	Calculate the answer. Insert the SI units.	(3)
12.1	$v = f\lambda$ ✓	Choose the appropriate formula.	
	$345 = 256 \times \lambda$✓	Substitute the values.	
	$\lambda = \dfrac{345}{256}$ ✓	Change the subject of the formula.	
	= 1,35 m✓	Calculate the answer. Insert the SI units.	(4)

12.2 An octave higher is 2× Middle C. ✓ The next octave higher than that is 2× (2× Middle C). Therefore, the note is 2 octaves higher than Middle C. ✓ (2)

12.3	$v = f\lambda$ ✓	Choose the appropriate formula.	
	345 = (4 x 256) ✓× λ	Substitute the values.	
	$\lambda = \dfrac{345}{4 \times 256}$ ✓	Change the subject of the formula.	
	= 0,34 m✓	Calculate the answer. Insert the SI units.	(4)

ALTERNATIVE METHOD

The frequency is 4 × as great as it was,

Therefore, the wavelength is ¼ × 1,35 m✓✓

λ = 0,34 m✓

12.4 **12.4.1** No change to the loudness ✓because the amplitude remains constant.✓ (2)

12.4.2 The pitch is higher✓ because the frequency is higher. ✓ (2)

13.1	Distance	= speed × time✓	Choose the appropriate formula.	
		= 1 450 × 3,5✓	Substitute the values.	
		= 5 075 m		
	Distance of submarine	= ½ × distance✓	Correct reasoning.	
		= ½ × 5 075		
		= 2 537,5 m✓	Calculate the answer. Insert the SI units.	(4)

13.2	$v = f\lambda$ ✓	Choose the appropriate formula.	
	$1\,450 = f \times 0{,}02$✓	Substitute the values.	
	✓	Convert cm to m.	
	f = 72 500 Hz✓	Calculate the answer. Insert SI units.	(4)

13.3 He must turn the volume up.✓ This increases the amplitude of the sound wave.✓ (2)

13.4 Frequency is not affected ✓by a change in the amplitude. ✓ (2)

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14.1 Ultrasound waves reflect off tissues✓ and are received by a computer. An image of the tissues is produced on a computer monitor. ✓Tissues of different densities reflect waves differently ✓so the internal organs and blood vessels can be identified in the image. ✓ (4)

14.2 **14.2.1** Ultrasound waves are safe; they do not have any ionising radiation which could affect delicate tissues. ✓ (1)

14.2.2 Ultrasound waves can reflect off soft tissue; X-rays cannot distinguish between different types of softer tissues.✓ (1)

14.2.3 Using ultrasound technology is much cheaper and easier to use than X-rays✓ (1)

15.1 Ordinary sound waves would be heard by animals and humans, ✓ and they could damage their ears because these waves are high energy waves of large amplitude (loudness). ✓ The waves must have large amplitudes because they have to travel great distances through water to the object and reflect back again. ✓While they travel the energy of the sound diminishes (decreases). It is important that the sound wave has sufficient energy to reflect and return to the transmitter without dying out on the way back. ✓ OR equivalent reasoning. (4)

15.2 SONAR = Sound Navigation And Ranging✓ (1)

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CONSOLIDATION EXERCISE

TOTAL: 32 MARKS

MULTIPLE CHOICE

1. C ✓✓ The vibrations that cause longitudinal waves move along the direction of the wave propagation. Because the wave is travelling forward, the vibrations will move forwards and backwards. (2)

2. A ✓✓ Wavelength is measured from the middle of one compression to the middle of the next successive compression. Option B describes the amplitude of the wave. Options C and D describe the measurement of half a wavelength. (2)

3. D ✓✓ The speed of sound in air remains constant (on the same day at the same temperature). Speed = frequency × wavelength. If frequency is doubled, then wavelength is halved. (2)

LONG QUESTIONS

4.1 Sonar✓ (1)

4.2

$v = f\lambda$✓ Choose the appropriate formula.

$340 = f \times 0{,}01$✓ Substitute the values.

$f = 34\ 000$ Hz✓ Calculate the answer, Insert the SI units.

Frequency must be greater than 34 000 Hz. ✓ Interpret the answer. (4)

4.3 34 000 Hz is ultrasonic because it is above the threshold of human hearing (20 000 Hz). ✓ If the sound was in the range of human hearing the bats would not be able to receive echoes back from small insects like mosquitoes. ✓ (2)

4.4

$v = \frac{\text{distance}}{\text{time}}$ ✓ Choose the appropriate formula.

$340 = \frac{1}{t}$ ✓ Substitute the values.

$t = \frac{1}{340}$ ✓ Change the subject of the formula.

$= 0{,}002941$ Calculate the answer.

$= 2{,}94$ ms✓ Convert s to ms (divide by 1 000). Insert SI units. (4)

5.1

$v = \frac{\text{distance}}{\text{time}}$ ✓ Choose the appropriate formula.

$5400 = \frac{12\ 000}{t}$ ✓ Convert km to m. Substitute the values.

$t = \frac{12\ 000}{5\ 400}$ ✓ Change the subject of the formula.

$= 2{,}22$ s✓ Calculate the answer. Insert SI units. (4)

5.2 $v = \frac{\text{distance}}{\text{time}}$

$340 = \frac{12\,000}{t}$ ✓ Substitute the values.

$t = \frac{12\,000}{340}$

$= 35{,}29$ s ✓ Calculate the answer.

Time $= 35{,}29 - 2{,}22$ ✓ Subtract the time from 2.1 (c.o.e.).

$= 33{,}07$ s ✓ Calculate the answer. Insert SI units. (4)

6.1 $v = \frac{\text{distance}}{\text{time}}$ ✓

$= \frac{2 \times 475}{3}$ ✓ Distance travelled by echo = 2 × 475 m
Substitute values.

$= 316{,}67\ \text{m·s}^{-1}$ ✓ Calculate the answer. (3)

6.2 Time difference between receiving the two echoes = 6,5 – 3 = 3,5 s
Reasoning. ✓

Distance travelled by the second echo in 3,5 s = 2 × distance between faces
Reasoning. ✓

Distance between two faces = ½ (speed × 3,5)

= ½ (316,67 × 3,5) ✓ Substitute the values.

= 554,17 m ✓ Calculate the answer.
Insert the SI units. (4)

ALTERNATIVE METHOD

Distance travelled by second echo $= vt$ Method ✓

= 316,67 × 6,5 ✓ Substitution

= 2058,36 m

Distance of 2nd face = ½ × 2058,36 ✓ = 1029,18 Reasoning

Distance between 2 mountain faces = 1029,18 – 475

= 554,18 m ✓ Calculate the answer.
Insert the SI units.

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WORKSHEETS

Topic 10: Electromagnetic Radiation

WORKSHEET

MULTIPLE CHOICE

1. Radio waves are …

A short wavelength electromagnetic waves.

B short wavelength sound waves.

C long wavelength electromagnetic waves.

D long wavelength sound waves. (2)

2. Electromagnetic radiation is classified as a transverse wave because …..

A it travels through a vacuum.

B it travels at the speed of light.

C the electric and magnetic fields are perpendicular to each other.

D the vibrations are perpendicular to the direction of propagation. (2)

3. A radio wave …

i) travels at the speed of sound.

ii) is received by a radio which increases the amplitude of the sound.

iii) is low energy electromagnetic radiation.

Which of the statements above is/are TRUE?

A (i) only.

B (i) and (ii) only.

C (ii) and (iii) only.

D (iii) only. (2)

4. The dual nature of electromagnetic radiation applies to …

A all electromagnetic radiation all the time.

B only electromagnetic radiation with frequencies above those of infrared radiation all of the time.

C all electromagnetic radiation when it interacts with materials such as metals.

D visible light only all of the time because its particles are called photons. (2)

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LONG QUESTIONS

5. A radio station broadcasts at a frequency of 105 kHz.

5.1 Calculate the wavelength of these radio waves. (4)

5.2 Briefly explain how a radio wave is transformed to a sound wave by a radio receiver. (4)

6. Give …

6.1 two pieces of evidence that prove that EM radiation is transferred by waves. (4)

6.2 one piece of evidence that proves that EM radiation is transferred by particles. (2)

7. The sun is about 150 million km away from the earth. Let us suppose that the sun stops shining. How long (in minutes) will it take people on earth to know that the sun has "switched off"? (6)

8. X-rays and gamma rays are high energy types of EM radiation. Sometimes the frequencies of X-rays and gamma rays overlap in their regions of the EM spectrum.

8.1 What is the difference between an X-ray and a gamma ray? (2)

8.2 A gamma ray of frequency 5×10^{20} Hz is produced from radioactive material. Calculate:

8.4.1 its period. (3)

8.4.2 its wavelength. (4)

8.3 Give one medical use of gamma rays, and briefly explain why gamma rays are effective in treating this medical condition. (2)

8.4 Give one use of X-rays. (1)

9. The atmosphere absorbs most of the infrared radiation that comes to earth from outer space. There is a band of wavelengths from 8 to 12 microns (8×10^{-6} to 12×10^{-6} m) which are not absorbed by any gases in the atmosphere. These infrared radiations help to warm up the planet.

9.1 Between which two regions of the EM spectrum does the region of infrared (IR) radiation lie? (2)

9.2 Calculate the frequency of infrared radiation with a wavelength of 10 microns. (4)

9.3 Give one use of infrared radiation. (1)

10. Briefly explain the harmful effects of excessive exposure to the following types of EM radiation.

10.1 microwaves (3)

10.2 infrared (3)

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11. A radio wave has a wavelength of 3 000 m whereas an X-ray has a wavelength of 3 picometres (3×10^{-12} m).

11.1 Calculate the frequency of the radio wave. (4)

11.2 Calculate the energy of a photon of the radio wave. (3)

11.3 Give two reasons why the photon of the X-ray is much more dangerous than the photon of the radio wave. (2)

12. **12.1** What is meant by the phrase "ionising radiation"? (2)

12.2 Name the regions of the EM spectrum which are classified as "ionising radiation" (2)

12.3 It is said that EM radiation given off by overhead electrical power lines is a health risk to those people who live under or near the power lines. The frequency of the electricity in the power lines is 50 Hz.

12.3.1 Calculate the wavelength of the EM radiation. (4)

12.3.2 Calculate the energy of photons of this radiation. (3)

12.3.3 Comment on whether this radiation is likely to be "ionising radiation". (2)

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CONSOLIDATION EXERCISE

TOTAL: 41 MARKS

MULTIPLE CHOICE

1. Which of the following lists shows EM radiation correctly arranged in order of increasing frequency?

A gamma rays, X-rays, microwaves, radio waves

B X-rays, gamma rays, microwaves, radio waves

C microwaves, radio waves, X-rays, gamma rays

D radio waves, microwaves, X-rays, gamma rays (2)

2. Which one of the following types of radiation is used to send a signal from a TV remote control device to change the channel on the TV?

A radio wave

B microwave

C infrared

D X-ray (2)

3. X-rays and ultrasound are useful medical diagnostic tools. Both these technologies are similar to one another in that they both …

A use EM radiation.

B are non-invasive imaging technologies.

C safe to use in examining infants and adults.

D require technicians to wear protective clothing when operating the machines. (2)

4. Which of the following occurs when the wavelength and the amplitude of EM radiation passing through a vacuum is increased?

A The frequency decreases and the intensity increases.

B The frequency and the intensity increases.

C The frequency and the intensity decreases.

D The frequency increases and the intensity decreases. (2)

5. Which one of the following affects the energy of the photons of EM radiation?

A amplitude

B period

C frequency

D the medium through which it passes (2)

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LONG QUESTIONS

6. The wavelength of four different types of EM radiation are shown in the table below.

EM RADIATION	WAVELENGTH
Visible light	0,0005 mm
A	1,2 km
B	100 mm
C	0,15 mm

6.1 Which of the radiations A, B or C, is an infrared wave? (2)

6.2 Calculate the frequency of the visible light waves. (4)

6.3 Which of the radiations in the table above will have the highest energy photons? Explain briefly. (3)

6.4 Visible light is able to penetrate transparent substances such as water. Light travels at 75% of its speed in a vacuum when it passes through water. Briefly explain how the following characteristics of light are affected when light travels through water:

6.4.1 the wavelength of light (2)
6.4.2 the frequency of light (2)
6.4.3 the energy of the photons of light (2)

7. After a boy hurts his arm by falling from a tree the doctor asks for a photograph (or digital image) to be taken of his arm so that he can check whether a bone has been broken.

7.1 What type of radiation would be used to produce the photograph? (2)

7.2 Describe how this radiation is able to produce an image of the bones of the arm. (4)

7.3 Calculate the energy of photons of this radiation if the frequency is $4,5 \times 10^{18}$ Hz. (3)

8. Radar stands for Radio Detection And Ranging. It can be used to measure distances. Radar makes use of microwaves.

8.1 What is a "microwave"? (2)

8.2 A ship lying stationary off the coast of the mainland, sends out radar signal to measure its distance from a port. The signal returns within 3,5 μs ($3,5 \times 10^{-6}$ s). What is the distance between the ship and the port? (4)

8.3 Give one other use of microwaves (besides being used for radar). (1)

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WORKSHEET MEMORANDUM

1. C✓✓ Electromagnetic waves with long wavelength (low frequency and low energy). (2)

2. D✓✓ A transverse pulse has the direction of disturbance at right angles (perpendicular) to the direction of propagation. The distractors in this question are all true statements, but they are not the reason why an electromagnetic wave is classified as a transverse wave. These distractors lift the cognitive level of this particular question from CL2 to CL3. (2)

3. D✓✓ Radio waves are long wavelength (low energy, low frequency) EM radiation. Radio waves are transformed to sound waves by the electric circuitry of the radio receiver. (2)

4. A✓✓ All EM radiation has a dual nature, and it has this dual nature all the time. Its particle nature is displayed when it interacts with other materials e.g. metals in the photo-electric effect. Its wave nature is shown when beams of EM radiation cross over each other. (2)

LONG QUESTIONS

5. **5.1**

$v = f\lambda$ ✓	Choose the appropriate formula.
3×10^8 ✓ $= 105 \times 10^3$ ✓ $\times \lambda$	Insert the speed of light. Convert kHz to Hz.
$\lambda = \frac{3 \times 10^8}{105 \times 10^2}$	Change the subject of the formula.
$= 2\,857{,}14$ m✓	Calculate the answer. Insert the SI units. (4)

5.2 When radio waves are received by the aerial of the radio, they excite electrons in the aerial, ✓ causing the electrons to accelerate up and down its length. These signals in the aerial are transformed to mechanical vibrations of the loudspeaker✓ by the electric circuit of the radio. ✓The vibrations of the cone of the loudspeaker produce sound waves which we hear. (4)

6. **6.1** EM radiation can be diffracted, ✓✓ and it can produce interference patterns.✓✓ (4)

6.2 EM radiation can release electrons from the surface of metals (the photoelectric effect).✓✓ (2)

7.

Distance = speed x time✓	Choose the appropriate formula.
$150 \times 10^6 \times 10^3$ ✓ $= 3 \times 10^8$✓ $\times$ time	Convert km to m. Insert the speed of EM radiation.
Time $= \frac{150 \times 10^6 \times 10^3}{3 \times 10^8}$ ✓	Change the subject of the formula.
$= 500$ ✓s	Calculate the answer. Ignore SI units.
$= \frac{500}{60}$ minutes	Convert time to minute.
$= 8{,}33$ minutes✓	Calculate the answer. Insert SI units. (6)

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8. **8.1** An X-ray is produced when a beam of electrons is slowed down rapidly by hitting a metal target. ✓
A gamma ray is emitted by the nucleus of a radioactive substance when protons and neutrons are shifted around in the nucleus (usually alpha or beta rays are emitted at the same time). ✓ (2)

8.2 **8.2.1** $T = \frac{1}{f}$ ✓ Choose the appropriate formula.
$= \frac{1}{5 \times 10^{20}}$ ✓ Substitute the value of frequency.
$= 2 \times 10^{-21}$ s ✓ Calculate the answer. Insert SI units (3)

8.2.2 $v = f\lambda$ ✓ Choose the appropriate formula.
3×108 ✓ $= 5 \times 10^{20} \times \lambda$✓ Insert the speed of light.
Substitute the value of frequency.
$\lambda = \frac{3 \times 10^8}{5 \times 10^{20}}$ Change the subject of the formula.
$= 6 \times 10^{-13}$ m✓ Calculate the answer. Insert the SI units. (4)

8.3 Gamma rays are used in the treatment of cancer. ✓
Gamma radiation is ionising radiation which kills living cells, therefore it is able to kill cancer cells. (2)

8.4 X-rays are used as a diagnostic tool in medicine to look for broken bones (fractures), and/or lung diseases. They are used in industry to check for breakages in metal pipes which are enclosed in concrete. And in security camera systems at airports. [Any ONE correct answer ✓] (1)

9. **9.1** microwaves ✓ and visible light ✓ (2)

9.2 $v = f\lambda$ ✓ Choose the appropriate formula.
3×10^8 ✓ $= f \times 10 \times 10^{-6}$ ✓ Insert the speed of light.
Substitute the value of frequency.
$f = \frac{3 \times 10^8}{10 \times 10^{-6}}$ Change the subject of the formula.
$= 3 \times 10^{13}$ m✓ Calculate the answer. Insert the SI units. (4)

9.3 Cooking; heating; night vision technologies; thermal imaging

[Any ONE correct answer✓] (1)

10. **10.1** Microwaves cause water molecules to move faster✓ which in turn warms up substances which contain water molecules. ✓ Our internal organs contain a lot of water therefore we would experience heating of our internal body cells (and organs). ✓ (3)

10.2 Infrared radiation warms (heats) things up✓ e.g. as in cooking, and temperature control of the house during cold weather✓. Over-exposure to infrared radiation would cause skin burns. ✓ (3)

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11. 11.1

v	$= f\lambda$ ✓	Choose the appropriate formula.	
3×10^8✓	$= f \times 3\ 000$✓	Insert the speed of EM radiation. Substitute the value of the wavelength.	
f	$= \frac{3 \times 10^8}{3\ 000}$	Change the subject of the formula.	
	$= 1 \times 10^5$ Hz✓	Calculate the answer. Insert the SI units.	(4)

11.2

E	$= hf$✓	Choose the appropriate formula.	
	$= 6{,}63 \times 10^{-34} \times 1 \times 10^6$✓	Insert Planck's constant. Substitute value of frequency (from 11.1)	
	$= 6{,}63 \times 10^{-28}$ J✓	Calculate the answer. Insert the SI units.	(3)

11.3 The X-ray photon produces ionising radiation whereas the radio wave does not. ✓ The energy of the X-ray photon is about 10^{15} times greater than the energy of the radio wave. ✓ (2)

12. 12.1 Radiation that removes electrons from atoms. ✓✓ (2)

12.2 Visible light; ultraviolet; X-rays, gamma rays ✓✓ (½ a mark each) (2)

12.3 12.3.1

v	$= f\lambda$✓	Choose the appropriate formula.	
3×10^8 ✓	$= 50 \times \lambda$✓	Insert the speed of light. Substitute the value of frequency.	
λ	$= \frac{3 \times 10^8}{50}$	Change the subject of the formula.	
	$= 6 \times 10^6$ m✓	Calculate the answer. Insert the SI units.	(4)

12.3.2

E	$= hf$✓	Choose the appropriate formula.	
	$= 6{,}63 \times 10^{-34} \times 50$✓	Insert Planck's constant. Substitute the value of the frequency.	
	$= 3{,}32 \times 10^{-32}$ J✓	Calculate the answer. Insert the SI units.	(3)

12.3.3 Non-ionising radiation. ✓
The energy of the photons is extremely low OR the frequency of radiation is much lower than that of visible light (10^{14} to 10^{15} Hz).✓ (2)

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CONSOLIDATION QUESTIONS

TOTAL: 41 MARKS

MULTIPLE CHOICE

1. D ✓✓ Refer to the EM spectrum diagram. (2)

2. C ✓✓ Infrared radiation is used TV (and other) remote control devices. (2)

3. B ✓✓ They are both non-invasive technologies – they do not require injections of surgical procedure for the doctors to "see" inside the body.
X-rays use EM radiation; ultrasound uses high frequency sound waves.
Ultrasound is safe to use with infants and all adults (even pregnant women).
No protective clothing is required to screen the technicians.
X-rays are ionising radiations; they can damage cells and tissues; technicians need to wear protective clothing when working with X-ray machines. (2)

4. B ✓✓ Because $v = f\lambda$, and v is constant for EM radiation passing through a vacuum, frequency must decrease when wavelength is increased. The intensity increases when the amplitude increases. (2)

5. C ✓✓ Because $E = hf$, when the frequency changes, the energy of the photon also changes. (2)

LONG QUESTIONS

6. **6.1** C ✓✓
Infrared radiation has longer wavelength than visible light because its region lies adjacent to visible light. Radiation A is a radio wave; radiation B is a microwave. (2)

6.2

$v = f\lambda$✓	Choose the appropriate formula.
3×10^8✓ $= f \times 0{,}0005$ ✓	Insert the speed of EM radiation. Substitute the value of the wavelength.
$f = \dfrac{3 \times 10^8}{0{,}0005}$	Change the subject of the formula.
$= 6 \times 10^{11}$ Hz✓	Calculate the answer. Insert the SI units. (4)

6.3 Visible light ✓ It has the shortest wavelength therefore it has the highest frequency. ✓ The energy of a photon is given by $E = hf$ (or the energy of a photon is directly proportional to its frequency or the energy of a photon increases when the frequency increases). ✓ (3)

6.4 **6.4.1** Frequency remains constant ✓ The wave is caused by an accelerating charge, which continues vibrating at the same rate. ✓ (2)

6.4.2 Wavelength decreases ✓because the speed decreases (frequency remains constant). ✓ (2)

6.4.3 The energy of the photons remains the same✓ because frequency remains constant ($E = hf$). ✓ (2)

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7. **7.1** X-rays✓✓ (2)

7.2 X-rays are high energy radiations✓ which can penetrate soft tissues such as skin and flesh, ✓ but they cannot penetrate dense materials ✓such as bone. X-rays reflect off bone. The reflected beam of X-rays is transformed by a computer into an image of the bone and displayed on a computer screen (or The bone prevents the X-rays from passing through so the photograph shows the place where bones are as white places on the photograph – or as the shadow of the bones). ✓ (4)

7.3

$E = hf$✓	Choose the appropriate formula.
$= 6{,}63 \times 10^{-34} \times 4{,}5 \times 10^{18}$✓	Insert Planck's constant.
	Substitute the value of the frequency.
$= 2{,}98 \times 10^{-15}$ J✓	Calculate the answer. Insert SI units. (3)

8. **8.1** A microwave is electromagnetic radiation✓ with a wavelength of a few centimetres in length. ✓ (2)

8.2

Distance = speed x time✓	Choose the appropriate formula.
$= 3 \times 10^{8} \times 3{,}5 \times 10^{-6}$ ✓	Substitute the values.
= 1 050✓ m	Calculate the answer.
	Ignore the SI units.

The radar wave travelled at total distance of 1 050 m.
The port is ½ x distance = ½ × 1 050 = 525 m✓ away.

Divide by 2.(Multiply by ½)
Insert the SI units. (4)

8.3 cooking; (tele)communications; cell phones
[Any ONE correct use of microwaves].✓ (1)

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FORMAL EXPERIMENT

FORMAL EXPERIMENT

GRADE 10 TERM 1: CHEMISTRY

The Heating and Cooling Curves of Water

50 Marks

This section provides guidance and assessment of the learner's knowledge and understanding when carrying out a virtual experiment using the NECT video of the same name.

If your class is carrying out the experiment using laboratory apparatus and taking down their own results, you must set up your classroom appropriately and give the learners the relevant instructions. You may find it useful to refer to the Technical Instructions which precede the Learner's Instructions while preparing for this experiment.

If the learners are proceeding with the virtual experiment, then continue with the NECT programme by using the information, handouts and marking guidelines contained in this section of this Resource Book.

Formal Experiment

TECHNICAL INSTRUCTIONS

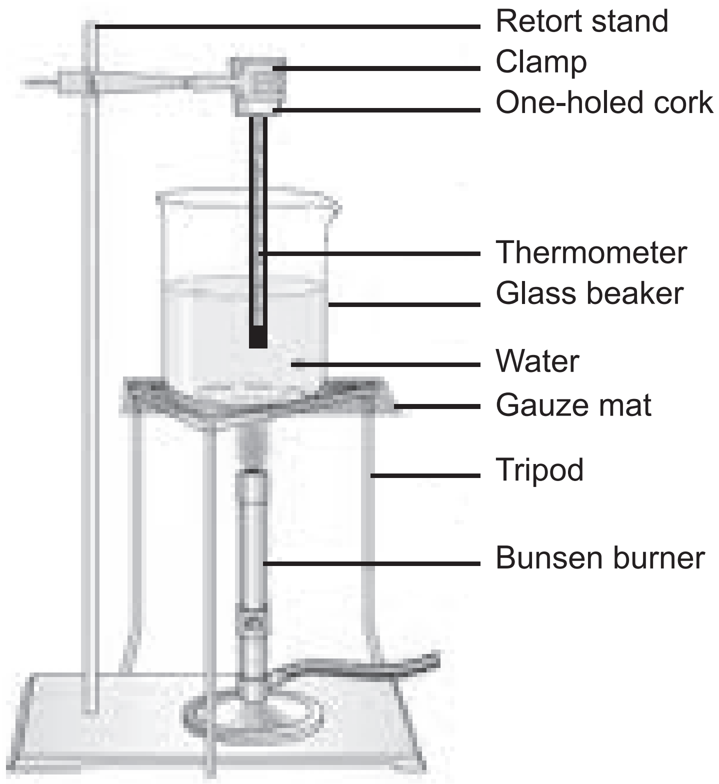
AIM: TO DRAW THE HEATING AND COOLING CURVE OF WATER.

APPARATUS:

Retort stand
Clamp
One-holed cork (to support the thermometer)
Thermometer
Glass beaker
Gauze mat
Tripod
Bunsen burner
Clock (or stopwatch)
Crushed ice in a bucket (or used ice-cream container)

METHOD

1. Set up the apparatus as shown in the diagram.



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2. Place sufficient crushed ice in the beaker to fully immerse the bulb of the thermometer.
3. Take the temperature of the ice.
4. Light the Bunsen burner and place it under the tripod so that it heats the ice in the beaker. Start the stopwatch.
5. At the end of one minute read the temperature of the contents of the beaker, and make a note of the phase of water in the beaker (solid, liquid or gas (boiling water)).
6. Repeat temperature readings (as outlined in step 5) until the water in the beaker has boiled for 3 minutes.
7. Extinguish the Bunsen burner flame, and remove the Bunsen burner from underneath the beaker.
8. Cool the water in the beaker by immersing the beaker of hot water into a bucket of crushed ice.
9. Start recording the temperature every minute for another 8 minutes.

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NAME: ____ GRADE:__________

Formal Experiment

HEATING AND COOLING CURVES OF WATER

AIM: TO DRAW THE HEATING AND COOLING CURVE OF WATER.

50 MARKS

THEORY:

A heating (and cooling) curve shows the changes from solid to liquid, liquid to gas (and vice versa) that a substance goes through when heated (or when cooled). The temperature of the substance remains constant during a phase change.

The heat source is adjusted once only so that the rate of heating remains constant during the experiment. In this way we can take the temperature of the water at equal intervals of time and know that the same amount of heat is being transferred to the water.

Similarly, the temperature of the crushed ice in the bucket remains constant while the hot water cools down.

The curves are plotted with temperature on the y-axis, and time on the x-axis. There are two features of the curve:

a) Regions at which the temperature remains constant (when a phase change takes place).

b) Regions at which the temperature increases (or decreases). No phase change occurs during these periods of time.

APPARATUS:

Retort stand
Clamp
One-holed cork (to support the thermometer)
Thermometer
Glass beaker
Gauze mat
Tripod
Bunsen burner
Clock (or stopwatch)
Crushed ice in a bucket (or used ice-cream container)

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SAFETY MEASURES OR PRECAUTIONS:

Use a lighter with an extender nozzle to light the Bunsen burner rather than using a match.

Have the lighter available before turning on the gas.

Never leave an open flame unattended.

Shut off the gas when you have finished heating the water.

Do not touch the Bunsen burner until it has cooled down.

Handle the beaker of hot water carefully, using tongs or insulated (oven) gloves.

VARIABLES

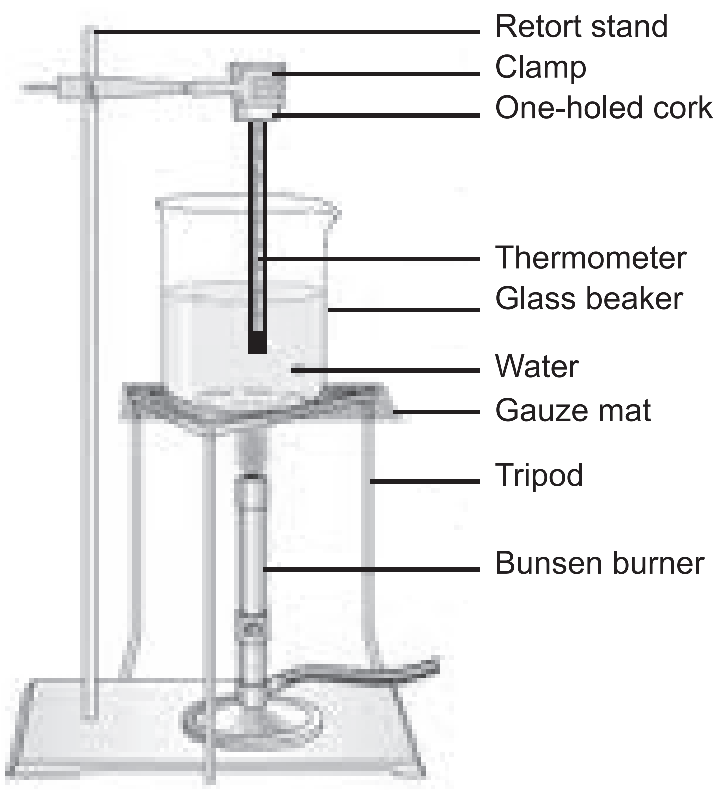
1. Identify the variables in this experiment.

- **Independent:** ____ **(1)**
- **Dependent:** ____ **(1)**
- **Controlled:** ____ **(2)**

  ____

METHOD:

1. Set up the apparatus as shown in the diagram.



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2. Place sufficient crushed ice in the beaker to fully immerse the bulb of the thermometer.
3. Take the temperature of the ice.
4. Light the Bunsen burner and place it under the tripod so that it heats the ice in the beaker. Start the stopwatch.
5. At the end of one minute read the temperature of the contents of the beaker, and make a note of the phase of water in the beaker (solid, liquid or gas (boiling water)).
6. Repeat temperature readings (as outlined in step 5) until the water in the beaker has boiled for 3 minutes.
7. Extinguish the Bunsen burner flame, and remove the Bunsen burner from underneath the beaker.
8. Cool the water in the beaker by immersing the beaker of hot water into a bucket of crushed ice.
9. Start recording the temperature every minute for another 8 minutes.

OBSERVATIONS AND RESULTS:

Watch the video and record the temperature readings as the ice is heated until the water boils.

Table 1A:

TIME (MINUTES)	TEMPERATURE (°C)	PHASE OF WATER
0		
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		

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15		
16		
17		
18		
19		
20		
21		
22		
23		
24		
25		
26		
27		
28		
29		
30		
31		
32		
33		
34		

Copy the results at 2 minutes intervals into Table 1B on the next page.

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<u>SUMMARY:</u> Copy the results from Table 1A neatly into Table 1B so that you can plot the points on the graph every 2 minutes. Write a title for this table of results.

2. Table 1B **(6)**

____

____

TIME (MINUTES)	TEMPERATURE (°C)	PHASE OF WATER
0		
2		
4		
6		
8		
10		
12		
14		
16		
18		
20		
22		
24		
26		
28		
30		
32		
34		

3. Predict the temperature of the water if it continued to boil for another 3 minutes.
At 37 minutes the temperature of the water will be ____________________ (1)

4. Watch the video, and record the temperature readings as the hot water cools down. Write a title for this table of results. (3)

____

____

TIME (MINUTES)	TEMPERATURE (°C)
0	
1	
2	
3	
4	
5	
6	
7	
8	

ANALYSIS AND INTERPRETATION

5. On the same piece of graph paper, plot two graphs of temperature against time as

5.1 ice is heated to boiling point, and (7)

5.2 hot water is cooled. (4)

Label each graph appropriately as "Heating curve" and Cooling curve".

6. During which time interval is the following happening?

6.1 Ice is melting: ________________________________ (2)

6.2 Water is boiling: ________________________________ (2)

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7. The gradient of the graph measures the change in temperature per minute (or the rate of change in temperature).

7.1 Write down a formula that can be used to determine the gradient of a graph. (2)

7.2 Calculate the gradient of the graph for these time intervals.

Show the relevant points that you used for these calculations on the graph.

7.2.1 <u>While water is warming up from its melting point to its boiling point.</u> (3)

7.2.2 <u>While water is boiling.</u> (3)

8. Now we analyse the cooling curve of water.

8.1 Describe the shape of the cooling curve of water. (2)

8.2 What does the shape of this curve tell us about the rate at which water cools down? Explain briefly. (4)

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CONCLUSION

9. Write a conclusion for this experiment. (3)

CONTROL QUESTIONS

The temperature of water is a measure of the average kinetic energy of the water particles. When the temperature of water remains constant (during melting and during boiling) the average kinetic energy of the particles remains constant, even though the water is being heated by the Bunsen flame. So, energy is being taken in by the water, but it is not being used to increase the kinetic energy of the particles.

10. What type of energy are the water particles gaining during a phase change?

(1)

11. Explain the answer (to Question 10) with reference to the kinetic theory of matter. (3)

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MARKING GUIDELINES

AIM: TO DRAW THE HEATING AND COOLING CURVE OF WATER.

50 MARKS

VARIABLES

1. Identify the variables in this experiment.

- **Independent**: Time ✓ (1)
- **Dependent**: Temperature ✓ (1)
- **Controlled**: Mass of water ✓ (2)
  Rate of heating (adjustment of heat source) ✓

OBSERVATIONS AND RESULTS:

2. **Table 1B**: The temperature and phase of ice (water) (OR similar description of the contents of the table).✓

TIME (MINUTES)	TEMPERATURE (°C)	PHASE OF WATER
0	0,0	✓solid
2	0,0	solid/liquid
4	2,5	✓ liquid
6	8,0	liquid
8	10,0	liquid
10	18,0	liquid
12	31,0	liquid
14	42,0	liquid
16	52,0	liquid
18	63,5	liquid
20	74,0	liquid
22	83,5	liquid
24	89,0	liquid
26	93,5	liquid
28	94,5	liquid
30	96,0	✓ boiling water or steam
32	96,0	boiling water or steam
34	96,0	boiling water or steam

✓accurate (according to the video)
✓all results have same number of decimals (6)

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3. Predict the temperature of the water if it continued to boil for another 3 minutes.

96 °C✓ (1)

4. <u>**Table 2**</u> Time and temperature for hot water cooling.
(OR similar descriptive title for the table.) ✓

TIME (MINUTES)	TEMPERATURE (°C)
0	45,5
1	35,0
2	29,0
3	25,0
4	22,0
5	19,0
6	17,0
7	15,5
8	14,5

✓ accurate (according to the video)
✓ all results have same number of decimals (3)

ANALYSIS AND INTERPRETATION

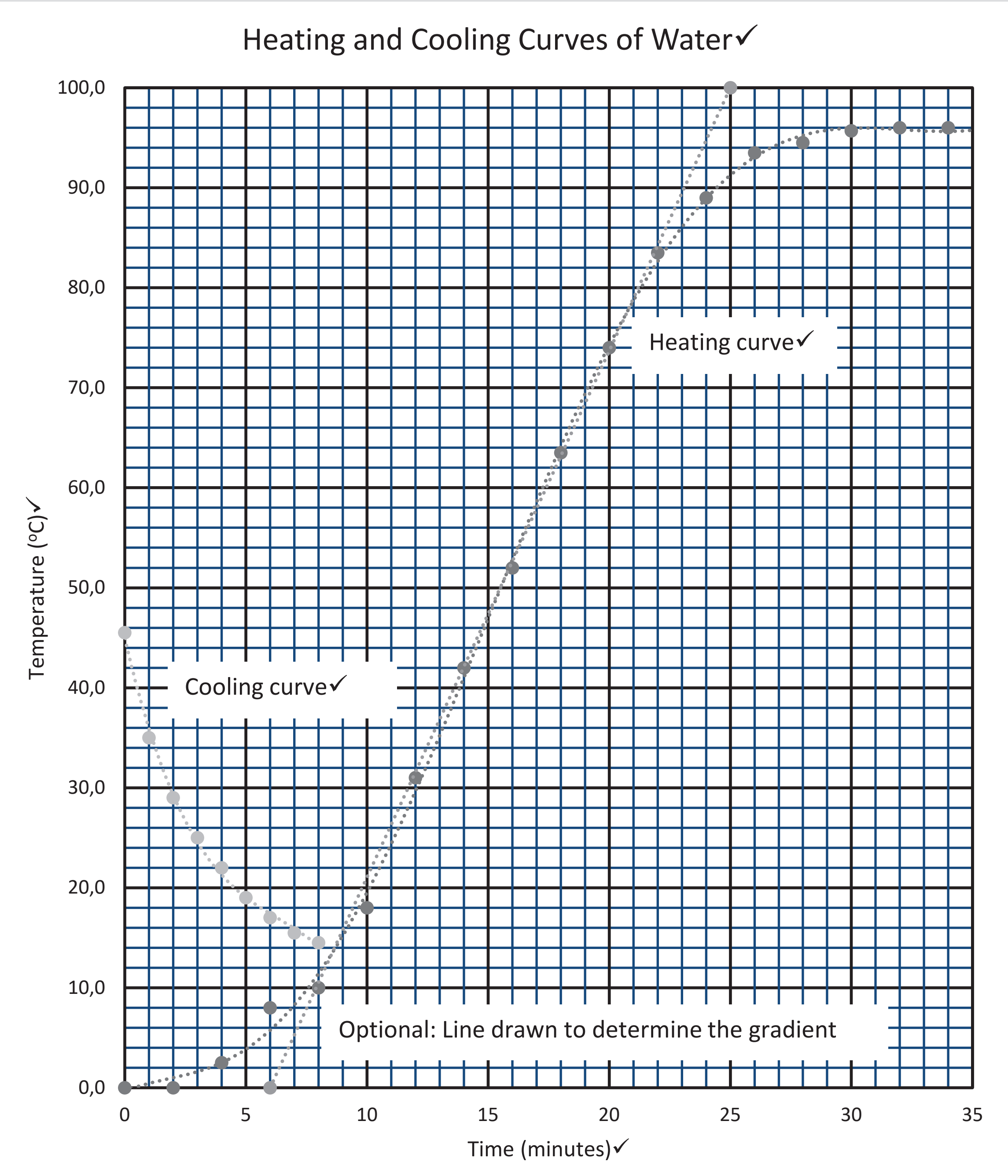
5. On the same piece of graph paper, plot two graphs of temperature against time as

4.1 ice is heated to boiling point, and

4.2 hot water is cooled.

Label each graph as "heating curve" and "cooling curve". (10)

PRACTICAL



Scales on both axes: Appropriate and with equal intervals ✓

Points plotted correctly: Heating curve: ✓ (Do not award this mark if any point is incorrect)

Cooling curve: ✓ (Do not award this mark if any point is incorrect)

Smooth "best fit" curve with correct shape: Heating curve ✓
Cooling curve ✓ (10)

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PRACTICAL

6. During which time interval is the following happening?

6.1 The ice is melting.

0 °C ✓ to 2 (or 3) °C ✓ (2)

6.2 The water is boiling.

30 °C ✓ to 34 °C ✓ (2)

7. The gradient of the graph measures the change in temperature per minute (or the rate of change in temperature).

7.1 Write down a formula that can be used to determine the gradient of a graph.

$$\text{gradient} = \frac{\Delta y}{\Delta x} \text{ OR } \frac{y_2 - y_1}{x_2 - x_1} \checkmark\checkmark$$ (2)

7.2 Calculate the gradient of the graph for these time intervals.
Show the relevant points that you used for these calculations on the graph.

7.2.1 <u>While water is warming up from its melting point to its boiling point:</u>

$\text{gradient} = \frac{y_2 - y_1}{x_2 - x_1}$ (6; 0,0) and (25; 100,0) [chosen from best-fit st. line]

$= \frac{100,0 - 0,0\checkmark}{25 - 6\checkmark}$ NB Any two valid coordinates to measure gradient.

$= 5,26 \checkmark\ °C{\cdot}min^{-1} \checkmark$ NB Accuracy (according to coordinates chosen)

Correct units (4)

7.2.2 <u>While water is boiling</u> (3)

$\text{gradient} = \frac{y_2 - y_1}{x_2 - x_1}\checkmark$ method

$= \frac{96,0 - 96,0}{34 - 32}\checkmark$ substitutions

$= 0 \checkmark\ °C{\cdot}min^{-1} \checkmark$ accuracy (Ignore units) (3)

8.1 Describe the shape of the cooling curve of water.

✓ the shape is curved; steeper at the beginning

✓ and flattening (slightly) as time goes on. (2)

8.2 What does the shape of this curve tell us about the rate at which water cools down? Explain briefly.

The steeper gradient (slope OR part) of the graph tells us that the rate of cooling is fastest✓ when the water is hottest. ✓

As the water cools down the rate of cooling slows down. ✓✓ (4)

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9. CONCLUSION (2)

When ice is heated, it melts, then warms up until its boils. ✓
During a phase change the temperature (of the water) remains constant. ✓
Hotter water cools faster than cooler water. ✓ (3)

CONTROL QUESTIONS

10. What type of energy are the water particles gaining during a phase change?
Potential energy ✓ (1)

11. Explain your reasoning (to Question 10) with reference to the kinetic theory of matter.

- ✓ Particles (or molecules) of water loosen their forces of attraction on each other when ice melts.
- ✓ The potential energy of molecules increases as they move apart from each other.
- ✓ When water boils, the molecules move very far apart from each therefore the water molecules have gained potential energy. (3)

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ASSESSMENTS

Topic 1: Matter and Classification

QUESTIONS

MULTIPLE CHOICE QUESTIONS

1. What is the correct name for the compound that has the chemical formula: NaOH?
   A sodium hydrogen oxide
   B sodium hydroxide
   C sodium oxyhydride
   D sodium oxygen hydrogen

2. What is the correct formula for lead(IV) sulfate?
   A $PbSO_4$
   B Pb_4SO_4
   C $Pb(SO_4)_2$
   D $Pb_2(SO_4)_4$

3. Consider the following statements about mixtures:
   I The components of a mixture combine chemically.
   II The components of a mixture can only be mixed in the correct proportions.
   III The components of a mixture can be separated by physical means.
   Which statement(s) is/are correct?
   A All of I, II and III are correct.
   B Only statement III is correct.
   C Only statements I and II are correct.
   D Only statement II is correct.

4. Which one of the following materials would be expected to have the lowest density at room temperature?
   A CO_2
   B lead
   C diamond
   D steel

5. A compound:
   A consists of only one type of atom.
   B consists of at least two atoms of different elements combined in any proportion.
   C can be separated into its elements by physical means.
   D consists of atoms of different elements which are chemically combined.

6. Which one of the following is NOT a physical property of a material?
   A Its ability to burn.
   B Its colour.
   C Its boiling point.
   D Its hardness.

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LONG QUESTIONS

7. You are provided with a mixture of iron filings and sulfur.
   7.1 Is this a pure substance? Give a reason for your answer. (2)
   7.2 Suggest a method for separating the iron filings from the sulfur. (2)
   7.3 What property of matter is being made use of in your answer to 1.2? (2)

8. The table, shown below, lists a set of substances in column A and in column B is a set of descriptions. Match the substance in column A with the appropriate description in column B.

Column A	Column B
Steel	A compound which has two elements
Table salt solution	A metal alloy
Copper	A heterogeneous mixture
Cement and sand	A homogeneous mixture
Carbon dioxide gas	An element

(10)

9. The table lists the melting points and boiling points of various substances.

Substance	Melting point (˚C)	Boiling point (˚C)
A	−114	78,4
B	113,7	184,3
C	−259,1	−252,9
D	1 538	2 862

Use the information in the table to answer the questions that follow. Briefly justify each of your answers.
Room temperature is 20 °C to 25 °C.
   9.1 Which substance(s) is/are solid at room temperature?
   9.2 Which substance is a gas at room temperature?
   9.3 Which substance is most likely to be a metal?
   9.4 Which substance is a liquid at room temperature?
   9.5 Which substance is most likely to be hydrogen? (12)

10. Consider the following substances listed below.

    aluminium, sand, nitrogen, pure air, sugar water, sugar, bronze.

Which of these substances is...
   10.1 a diatomic gas?
   10.2 a homogeneous mixture?
   10.3 an element?
   10.4 a heterogeneous mixture?
   10.5 a compound?
   10.6 a metal alloy? (12)

ASSESSMENTS

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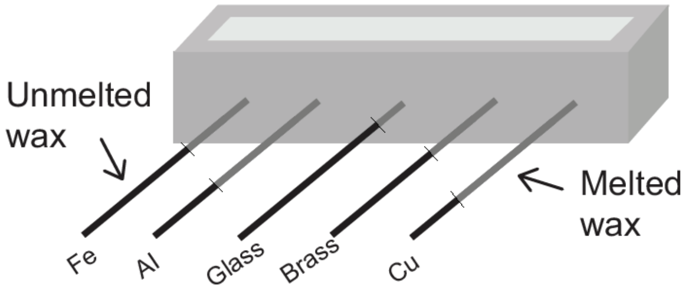
11.



The apparatus illustrated above is used to investigate the thermal conductivity of materials. The container is filled with hot water and the rods of material are in contact with the hot water. The rods are covered with wax. The diagram has each rod marked with a line to show how much wax has melted on each rod.

11.1 Which material is the best thermal conductor? Explain why this so. (4)

11.2 Which material is the poorest thermal conductor? Explain why this so. (4)

12. Explain why each of the following materials is suitable for the task described:

12.1 Aluminium is used to make car bodies.

12.2 Graphite is used to make electrodes in electrolytic cells.

12.3 'Vacuum flasks' have a double glass wall in which the gap between the walls contains air.

12.4 Steel is used as structural support in making buildings. (8)

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MARKING GUIDELINES

MULTIPLE CHOICE QUESTIONS

1. B ✓ ✓ The hydroxide ion has the formula OH^-. When it combines with sodium, the compound is called sodium hydroxide. [CL 2] (2)

2. C ✓ ✓ Lead(IV) means a lead ion with a charge of +4, i.e. Pb^{4+}. The sulfate ion is SO_4^{2-}. In order for the charges to balance there must be two sulfate ions for every lead(IV) ion. [CL 3] (2)

3. B ✓ ✓ The components of a mixture do not combine chemically and they do not have to be mixed in fixed ratios. They can be mixed in any proportion. [CL 2] (2)

4. A ✓ ✓ CO_2 is gas at room temperature, whereas the others are all solids. Solids have higher densities than gases. [CL 2] (2)

5. D ✓ ✓ There must be atoms of at least two elements in a compound. The atoms must combine in fixed proportions and they can only be separated by chemical means. [CL 3] (2)

6. A ✓ ✓ The ability to burn is a chemical property. The others are all physical properties. [CL 2] (2)

LONG QUESTIONS

7. 7.1 It is not a pure substance. ✓ OR No.
   It is a mixture of iron atoms and sulfur atoms. ✓ [CL 1] (2)
   7.2 By making use of a magnet to attract the iron filings. ✓ ✓ [CL 2] (2)
   7.3 The fact that a magnet attracts other magnetic materials. ✓
   OR By dissolving the sulfur in a suitable solvent. ✓
   Iron is magnetic. ✓ [CL 2] (2)

8.

Column A	Column B	Reasoning
Steel	A metal alloy ✓✓	Steel is an alloy (mixture) of iron and other metals
Table salt solution	A homogeneous mixture ✓✓	Once the salt is dissolved in the water, we cannot distinguish between the water and the salt.
Copper	An element✓✓	Pure copper contains nothing but copper atoms. It is a metal and an element.
Cement and sand	A heterogenous mixture ✓✓	We can distinguish the sand from the cement in the mixture
Carbon dioxide gas	A compound that has two elements ✓✓	It is made up of one carbon atom and two oxygen atoms.

[CL 3] (10)

ASSESSMENTS

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9. 9.1 B and D. ✓✓ Both have melting points that are much higher than room temperature. ✓ ✓
   9.2 C ✓ It has a boiling which is well below room temperature. ✓
   9.3 D ✓ It has much higher melting points and boiling points than any of the other substances. ✓
   9.4 A ✓ Room temperature lies between its melting point and its boiling point. ✓
   9.5 C ✓ It is the only one that is a gas at room temperature. ✓ [CL 3] (12)

10. 10.1 Nitrogen gas. ✓ ✓ It is diatomic, meaning that its molecules each contain two atoms.
    10.2 Either pure air or sugar water. ✓ ✓ Both are homogeneous mixtures. The gases that make up air cannot be distinguished and neither can the sugar once it's been dissolved in the water.
    10.3 Nitrogen ✓ ✓ is an element. It is made up of N_2 molecules, so it contains atoms of one element only. Aluminium is also an element – it is made up aluminium atoms only. (Either answer is acceptable).
    10.4 Sand ✓ ✓ It is made up many substances which can include fine sand, tiny rock crystals, soil, etc.
    10.5 Sugar ✓ ✓ is a compound. Its molecules contain atoms of carbon, hydrogen and oxygen.
    10.6 Bronze ✓ ✓ it is an alloy of copper and tin. [CL 3] (12)

11. 11.1 Copper. ✓ ✓ The length of melted wax is the longest. ✓✓ All the metals have most of the wax welted on them. Metals are good conductors of thermal energy, but copper is the best one of these metals. [CL 3] (4)
    11.2 The least amount of melted wax is on the glass, which means it does conduct heat very well. ✓ ✓ Glass is an insulator. It does not allow thermal energy to pass through it. ✓ ✓ [CL 3] (4)

12. 12.1 Aluminium is light ✓ and it can be shaped easily because it is malleable. ✓
    12.2 Graphite is a pure form of carbon – it is light and cheap. ✓ It is also a good conductor of electricity. ✓
    12.3 Air is a good thermal insulator ✓ and it is plentiful and readily available. ✓ It will not affect the environment.
    12.4 Steel is strong ✓ and it does not corrode easily. ✓ This makes it very suitable for making strong, long-lasting structures. [CL 4] (8)

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Topic 2: States of Matter and the Kinetic Molecular Theory

QUESTIONS

MULTIPLE CHOICE QUESTIONS

1. The change of state from a gas or a vapour to a liquid is called:
   A evaporation.
   B sublimation.
   C condensation.
   D freezing. (2)

The following table contains the information for questions 2–6.

Substance	Melting point (˚C)	Boiling point (˚C)
Water	0	100
Ethanol	−11,5	78
Sulfur	115,2	444,6
Aluminium	660,4	2467,0
Carbon dioxide	−78,5	−78,5

Assume room temperature to be 25 °C.

2. Which substance is a liquid at room temperature?
   A ethanol
   B sulfur
   C aluminium
   D carbon dioxide (2)

3. Which substance undergoes sublimation?
   A water
   B ethanol
   C sulfur
   D carbon dioxide (2)

4. Which substance is a solid at room temperature?
   A water
   B sulfur
   C ethanol
   D carbon dioxide (2)

5. Which substance is a gas at room temperature?
   - A water
   - B ethanol
   - C aluminium
   - D carbon dioxide (2)

6 The particles of which substance will have the greatest amount of kinetic energy at room temperature?
   - A water
   - B ice
   - C phosphorus
   - D helium (2)

LONG QUESTIONS

7. Explain why the boiling points of substances are always higher than their melting points. (4)

8. Pentane (b.p 36 °C) and octane (b.p. 125 °C) are two organic compounds both of which are liquid at room temperature. Octane is a component of petrol.
   - 8.1 Explain why octane has a higher boiling point than pentane. (2)
   - 8.2 Explain how you could separate a mixture of these two liquids based on the information given. (4)

9. Sketch the cooling curve of a substance that is cooled from the gas state. The substance has a melting point of 18 °C and a boiling point of 87 °C. Label the axes correctly and insert the necessary values. (6)

10. Carbon dioxide sublimes at −78,5 °C.
   - 10.1 In terms of intermolecular forces, explain what happens during the process of sublimation of carbon dioxide. (3)
   - 10.2 What can be deduced about the intermolecular forces in carbon dioxide by the fact that it sublimes? (2)

11. Explain what happens in terms of intermolecular forces and energy changes during the water cycle. Mention the evaporation, condensation and freezing processes. (9)

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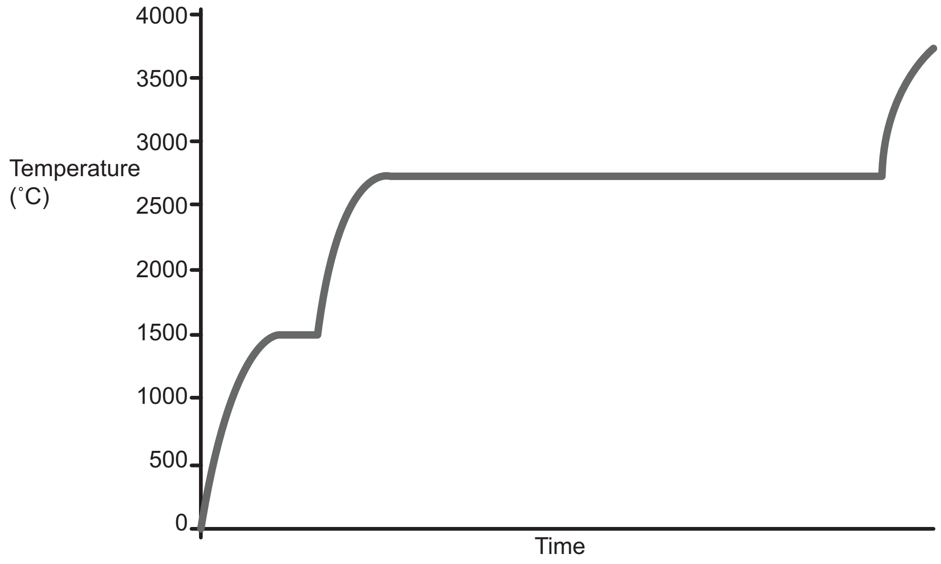
12. Consider the heating curve of substance A.



Refer to this graph to answer the questions that follow.

12.1 What is the melting point of substance A? Explain your answer. (4)

12.2 What is the boiling point of substance A? Explain your answer. (4)

12.3 In what state is substance A at 3 500 °C? Explain your answer. (3)

12.4 In what state is substance A at 1 000 °C? Explain your answer. (3)

MARKING GUIDELINES

MULTIPLE CHOICE

1. C ✓ ✓ Evaporation occurs when a substance changes from a liquid to a gas. Freezing occurs when a substance changes from a liquid to a solid. Sublimation occurs when a substance changes from a solid directly into its gas. [CL 1] (2)

2. A ✓ ✓ Sulfur and aluminium both have melting points above room temperature, so they are still solid at room temperature. Carbon dioxide is already a gas at room temperature as its sublimation point is below 20 °C. [CL 3] (2)

3. D ✓ ✓ Carbon dioxide has the same melting point and boiling point, so it sublimes at this temperature. [CL 3] (2)

4. B ✓ ✓ Room temperature lies between the melting point and boiling point of both water and ethanol, so both are liquids at room temperature. Carbon dioxide sublimes at a temperature below 20 °C, so it is a gas. [CL 3] (2)

5. D ✓ ✓ The boiling points of water, ethanol and aluminium are all well above room temperature. Carbon dioxide sublimes at a temperature below 20 °C, so it is a gas at room temperature. [CL 3] (2)

6. D ✓ ✓ Helium is a gas at room temperature, water is a liquid and ice and phosphorus are both solids. The particles of gases at a given temperature have more kinetic energy than those of solids or liquids. [CL 3] (2)

LONG QUESTIONS

7. When a substance melts, the interparticle forces just become weaker ✓ and it takes relatively little energy for that to happen. ✓ When a substance boils, the interparticle forces have to be broken completely ✓ and that requires a lot more energy. ✓ [CL 3] (4)

8. 8.1 The intermolecular forces between the molecules of octane are stronger than those between molecules of pentane. ✓ Less energy is required to separate the molecules of pentane than those of octane. ✓ [CL 3] (2)

   8.2 Since the two liquids have very different boiling points, they could be separated on this basis. ✓ The mixture could be heated to 36 °C, at which point the pentane would boil. ✓ The pentane vapour given off could be collected and allowed to cool to obtain pure pentane. ✓ The liquid left in the container should be pure octane. ✓ [CL 4] (4)

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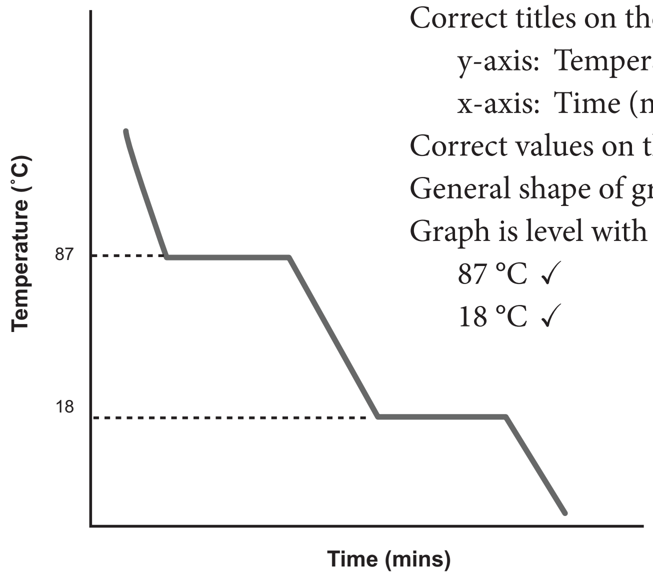
9.



Correct titles on the axes:
y-axis: Temperature (°C) ✓
x-axis: Time (minutes) ✓
Correct values on the y-axis ✓
General shape of graph ✓
Graph is level with the x-axis at:
87 °C ✓
18 °C ✓

[CL 3] (6)

10. 10.1 In solid carbon dioxide there are forces holding the particles together. ✓ The solid exists at −78,5 °C. If the temperature goes above this value, there is sufficient energy ✓ to break the intermolecular forces completely and the carbon dioxide changes to a gas. ✓ [CL 3] (3)

10.2 The deduction to be made from the fact that carbon dioxide sublimes is that the intermolecular forces are extremely weak. ✓ ✓ [CL 2] (2)

11. When water evaporates from the surface of the Earth, it does so because there are water molecules with sufficient energy to leave the surface of the water ✓ and escape into the atmosphere, because they are able to overcome the intermolecular forces holding them to the other molecules. ✓ When the sun is shining and it is hot the water absorbs more energy and the process is speeded up. ✓
When the water vapour reaches the upper layers of the atmosphere it cools down ✓ and the molecules lose energy. ✓ The intermolecular forces become stronger and pull the molecules together and the water condenses to a liquid. ✓
If the temperature is sufficiently low, the water molecules in the liquid state lose even more energy ✓ and come even closer together, ✓ the intermolecular forces become stronger and the liquid becomes solid (ice). ✓ [CL 3] (9)

12. 12.1 Melting point is 1 500 °C. ✓ This is the first time that the graph is 'flat' ✓ so a change of state is taking place. ✓ Since it is the first time it occurs and the substance started out as a solid, this is the melting point. ✓ [CL 3] (4)

12.2 Boling point is about 2 800 °C. ✓ Once again the graph is flat here ✓ meaning that the temperature is constant so the substance is changing state. ✓ This is the boiling point. ✓ [CL 3] (4)

12.3 It is a gas at 3 500 °C. ✓ The substance has undergone the change of state from liquid to gas at its boiling point, ✓ which is at about 2 800 °C. ✓ [CL 3] (3)

12.4 The substance is a solid at 1 000 °C. ✓ Its melting point is 1 500 °C, so at this temperature ✓ it hasn't yet undergone the change of state from solid to liquid. ✓ [CL 3] (3)

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Topic 3: The Atom: Building Block of Matter

QUESTIONS

MULTIPLE CHOICE

1. Which one of the following statements is correct about element Q, represented by $^{56}_{26}Q^{2+}$. It has ...
   A more electrons than protons.
   B more protons than neutrons.
   C 56 nucleons.
   D 56 neutrons. (2)

2. What does it mean when we describe the electron configuration of atom as being *a ground state configuration*?
   A All the electrons are paired.
   B All the electrons are in their lowest possible energy state.
   C All the electrons are unpaired.
   D At least one electron has moved to a higher energy state. (2)

3. Which one of the following atoms has the greatest number of unpaired electrons?
   A $_{13}Al$
   B $_{16}S$
   C $_{9}F$
   D $_{15}P$ (2)

4. Which model of the atom consisted of a central nucleus surrounded by electrons orbiting the nucleus at several fixed distances from it?
   A Bohr model
   B Rutherford model
   C Dalton model
   D Thomson model (2)

5. The ion of a particular atom has a charge of +3. Which one of the following statements best describes how the atom became an ion?
   A It has gained 3 electrons.
   B It has lost 3 electrons.
   C It has gained 3 protons.
   D It has lost 3 protons. (2)

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6. Consider the element sulfur. Which one of the following is likely to be the mass number of the most abundant isotope of sulfur?
   A 30
   B 32
   C 33
   D 34 (2)

LONG QUESTIONS

7. State the following in words:
   7.1 Aufbau principle (2)
   7.2 Pauli's exclusion principle (3)
   7.3 Hund's rule (3)

8. An element has three naturally occurring isotopes:
   Mass number 206 abundance 23,20%
   Mass number 207 abundance 2x%
   Mass number 208 abundance x%
   Calculate the percentage abundance of each of the isotopes 207 and 208, if the element has a relative atomic mass of 207,68. (6)

9. Give the electron configuration of:
   9.1 an atom of calcium. (2)
   9.2 a stable ion of calcium (2)
   9.3 an atom of calcium in an excited state. (2)

10. Consider these two isotopes: $^{64}_{29}Cu$ and $^{66}_{29}Cu$.
    10.1 Define the term *isotopes*. (2)
    10.2 Are the two isotopes of the same element? Give reasons for your answer, including specific numbers of particles. (4)

11. Consider these two isotopes: $^{106}_{47}Ag$ and $^{108}_{47}Ag^{+}$. Give
    11.1 two similarities and (2)
    11.2 two differences between these two atoms. (2)
    Be very specific in your answers, regarding numbers of particles.

12. Correct the following statement giving a detailed explanation for your answer:
    'The mass number of aluminium is 26,98'. (6)

ASSESSMENTS

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MARKING GUIDELINES

MULTIPLE CHOICE

1. C ✓ ✓ Nucleons refers to particles belonging in the nucleus of an atom, i.e. protons and neutrons. The total number of protons and neutrons is the mass number, which is top left in the standard notation and its value is 56. The nuclide has lost two electrons, so it will have fewer electrons than protons. No stable isotope of an atom has more protons than neutrons. [CL 3] (2)

2. B ✓ ✓ Electrons are in their ground state when all the electrons have been distributed according to the Aufbau principle, Pauli's exclusion principle and Hund's rule. They are all thus in their lowest possible energy state. [CL 2] (2)

3. D ✓ ✓ 'Unpaired electrons' refers to single electrons occupying an orbital. The outer electron configuration of phosphorus is $3s^2 3p_x^1 3p_y^1 3p_z^1$. It thus has three unpaired electrons. Aluminium has one, sulfur has two and fluorine has one. [CL 3] (2)

4. A ✓ ✓ Rutherford's model also had electrons moving around the nucleus but not in fixed regions. [CL 1] (2)

5. B ✓ ✓ The ion has a charge of +3. This means that it has lost three electrons, which have a negative charge. Atoms cannot gain or lose protons in chemical reactions. [CL 2] (2)

6. B ✓ ✓ The relative atomic mass of sulfur (which is the weighted average of the mass numbers of all its isotopes) is 32,07. So, the most abundant isotope is likely to be the one that has the closest mass number to 32. [CL 3] (2)

LONG QUESTIONS

7.
   7.1 When electrons are distributed into orbitals and energy levels, they must occupy the lowest energy level first. ✓ When that is full, the next energy level is filled ✓ and so on. [CL 1] (2)

   7.2 Pauli's exclusion principle states: Only two ✓ electrons of opposite spin ✓ may occupy an orbital. ✓ [CL 1] (3)

   7.3 Hund's rule states: When orbitals of equivalent energy are being filled, ✓ each orbital must be filled singly ✓ before any orbital can have two electrons. ✓ [CL 1] (3)

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8. Assume a sample of 100 atoms.

$$\text{Relative atomic mass} = \frac{(206 \times 23,20) + (207 \times 2x) + (208x)}{100}$$

$$207,68 = \frac{4\,779,20 + 414x + 208x}{100}$$

$$207,68 = 4\,779,20 + 622x$$

x = 25,71 ✓

Abundance of isotope 208 = 25,71% ✓
Abundance of isotope 207 = 51,42% ✓ [CL 4] (6)

9. 9.1 $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$ ✓ ✓ [CL 3] (2)
   9.2 $1s^2 2s^2 2p^6 3s^2 3p^6$ ✓ ✓ [CL 3] (2)
   9.3 $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 5p^1$ ✓ ✓ [CL 3] (2)
   The last electron can occupy any orbital higher in energy than 4s.

10. 10.1 Isotopes are atoms that have the same atomic number ✓ but different mass numbers. ✓ [CL 1] (2)
    10.2 Yes, they are isotopes of the same element. ✓ They both have 29 protons. ✓ The first nuclide has 35 neutrons ✓ and the second has 37 ✓ neutrons. [CL 3] (4)

11. 11.1 Similarities: they have the same number of protons – 47 ✓
    they are atoms of the same element ✓ [CL 3] (2)
    11.2 Differences: the first has 59 neutrons, the second has 61 ✓
    the first has 47 electrons, the second has 46 ✓ [CL 3] (2)

12. The correct statement should read: The relative atomic mass of aluminium is 26,98. ✓
    Mass number is the sum of protons and neutrons ✓ in the nucleus of an atom and must be a whole number. It only applies to individual atoms. ✓
    Relative atomic is the weighted average ✓ of the individual mass numbers ✓ of the all the isotopes of that element. ✓ That is why it can be a fractional number.
    [CL 3] (6)

ASSESSMENTS

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Topic 4: The Periodic Table

QUESTIONS

MULTIPLE CHOICE

1. The elements in group 17 of the Periodic Table are known as the:
   A alkali metals.
   B noble gases.
   C halogens.
   D alkaline earth metals. (2)

2. Which of the following correctly describes the trend in ionisation energy? Ionisation energy ...
   A increases down groups and across periods.
   B increases down groups and decreases across periods.
   C decreases down groups and across periods.
   D decreases down groups and increases across periods. (2)

3. Which element. represented by the its electron configuration, will have the highest first ionisation energy?
   A $1s^2$
   B $1s^2 2s^1$
   C $1s^2 2s^2 2p_x^1$
   D $1s^2 2s^2 2p_x^1 2p_y^1 2p_z^1$ (2)

4. What is the trend for atomic radius? Atomic radius ...
   A decreases down a group.
   B remains constant across a period.
   C increases down a group.
   D increases across a period. (2)

5. What is the connection between first ionisation energy and electronegativity for group 1 elements? From top to bottom in the group:
   A ionisation energy increases and electronegativity decreases.
   B ionisation energy and electronegativity both decrease.
   C ionisation energy decreases and electronegativity increases.
   D ionisation energy and electronegativity both increase. (2)

6. Which one of the following statements describes atoms of the element which is the most reactive non-metal?
   A Low electron affinity and large atomic radius.
   B Low electron affinity and small atomic radius.
   C High electron affinity and small atomic radius.
   D High electron affinity and large atomic radius. (2)

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LONG QUESTIONS

7. Explain the difference between electron affinity and electronegativity. (6)
8. Give an explanation for the fact that fluorine is the most reactive element in group 17 of the Periodic Table. (4)
9. The ionisation energy for sodium is 496 $kJ \cdot mol^{-1}$ while that for chlorine in the same period is 1 251 $kJ \cdot mol^{-1}$.
   9.1 What is meant by period in this context? (2)
   9.2 What can we deduce from the ionisation energies given? (3)
   9.3 Does this mean that sodium is more reactive than chlorine? Give scientific reasons to justify your answer. (4)
10. The element magnesium has two valence electrons which do not require the same energy to remove them.
    10.1 Give an explanation for the fact that energy is needed to remove an electron from an atom. (3)
    10.2 Do you think that more or less energy is needed to remove the second valence electron from an atom of magnesium than the amount needed to remove the first electron? Justify your answer with a scientific argument. (5)
11. The elements in group 2 react readily with the halogens.
    11.1 Are group 2 elements metals or non-metals? (1)
    11.2 Write down a word equation for the reaction between calcium and fluorine. (3)
    11.3 Write down the chemical formula for the substance that forms during the reaction in 11.2. (2)
12. The element astatine (As) is an element in group 17 of the Periodic Table. Answer the questions that follow on comparing the properties of astatine with those of other elements in group 17.
    12.1 What state would you expect astatine to be in at room temperature? Give a reason for your answer. (2)
    12.2 Compare the atomic radius of astatine with that of the other elements in group 17. Give a reason for your answer. (2)
    12.3 How would the electron affinity of astatine compare with that of the other elements in the group? Give a reason for your answer. (2)
    12.4 How would the first ionisation energy of astatine compare with that of the other elements in the group? Give a reason for your answer. (2)

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MARKING GUIDELINES

MULTIPLE CHOICE

1.1 C ✓ ✓ [CL 1] (2)

2. D ✓ ✓ From top to bottom in a group, the atoms get bigger, so the valence electrons are further away from the nucleus and it requires less energy to remove them. In going from left to right across a period the atoms get smaller, the valence electrons are closer to the nucleus and more energy is needed to remove them. [CL 2] (2)

3. A ✓ ✓ The electron configuration is that of helium, which is a noble gas. Helium only has electrons in the first energy level, which is full when occupied by two electrons. [CL 3] (2)

4. C ✓ ✓ In going from top to bottom in a group, the atoms have an extra energy level, with each added period. Atomic radius increases. [CL 2] (2)

5. B ✓ ✓ Atoms have a bigger atomic radius the further down a group they are. So, ionisation energy decreases. In the table of electronegativities it may be seen that it decreases down group 1. [CL 3] (2)

6. C ✓ ✓ High electron affinity means a strong attraction for electrons, hence higher reactivity. The smaller the atomic radius, the stronger the attraction for electrons, hence higher reactivity. [CL 4] (2)

LONG QUESTIONS

7. Electron affinity is a quantity that can be determined experimentally. ✓ It measures the ability of an atom to attract ✓ a **single**, **isolated** electron to itself. ✓ Electronegativity is a quantity that was calculated, not obtained by experiment. ✓ It measures the ability of atom to attract a **shared pair** ✓ of electrons in a bond. ✓
   [CL 3] (6)

8. Fluorine is the most reactive element in group 17 because it has the highest electron affinity, ✓ i.e. ability to attract an electron. It is the smallest atom in the group ✓ and the valence electrons are close to the nucleus ✓ and attracted strongly by it. ✓ [CL 2] (4)

9. 9.1 Period is the name given to the horizontal rows in the Periodic Table. ✓ ✓
   [CL 1] (2)

   9.2 We can deduce that the amount of energy needed to remove ✓ a valence electron from an atom of chlorine is greater ✓ than the energy needed to remove a valence electron from an atom of sodium. ✓ [CL 2] (3)

   9.3 No, sodium is a metal. ✓ Ionisation energies are relevant to the reactivity of metals because they lose electrons in chemical reactions ✓ . Chlorine is a non-metal ✓ and electron affinity is far more relevant to non-metals ✓ in order to determine their reactivity. [CL 4] (4)

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10. 10.1 Electrons are held in place around the nucleus by the electrostatic attraction between the positive nucleus and the negative electrons. ✓ Energy is required ✓ to break the attraction ✓ and release the electron from the nucleus. [CL 3] (3)

10.2 It requires more energy to remove the second electron. ✓ Once the first electron has been removed, the number of protons remains the same ✓ and they are now attracting one fewer electrons, ✓ so the second electron is more strongly attracted to the nucleus. ✓ More energy is required to break the stronger attraction. ✓ [CL 4] (5)

This question refers to the second ionisation energy of an element. It should be made clear that there isn't just one ionisation energy.

11. 11.1. Group 2 elements are metals. [CL 1] (1)

11.2 calcium✓ + fluorine✓ $\longrightarrow$ calcium fluoride✓ [CL 2] (3)

11.3 CaF_2 ✓ ✓ [CL 2] (2)

12. 12.1 Solid. ✓ It is at the bottom of the group and the other element just above it (iodine) is also a solid. ✓ [CL 2] (2)

12.2 It will be greater than all the others. ✓ It is at the bottom group and will have the greatest number of occupied energy levels. ✓ [CL 2] (2)

12.3 It would be smaller than the other elements. ✓ Being the biggest atom in the group, means that the valence electrons are furthest from the nucleus and the attraction for electrons will be weakest. ✓ [CL 3] (2)

12.4 It would be the smallest. ✓ Ionisation energy decreases from top to bottom in a group. ✓ [CL 2] (2)

ASSESSMENTS

Topic 5: Chemical Bonding

QUESTIONS

MULTIPLE CHOICE

1. Which one of the following substances does not contain molecules?
   A CO_2
   B CH_4
   C KCl
   D NF_3 (2)

2. An atom of fluorine has 10 electrons. The atom has become:
   A a molecule.
   B a cation.
   C an anion.
   D neutral. (2)

3. Which one of the following elements becomes a positive ion when it reacts to form an ionic bond?
   A carbon
   B sodium
   C chlorine
   D argon (2)

4. The number of shared pairs of electrons in a molecule of CO_2 is:
   A 1
   B 2
   C 3
   D 4 (2)

5. When a chemical bond forms between two atoms of nitrogen, electrons:
   A are shared equally between the atoms.
   B are transferred from one to the other.
   C form only single bonds.
   D form only double bonds. (2)

6. An atom of potassium differs from an ion of potassium in that:
   A the atomic number of the atom is greater than that of the ion.
   B the ion has one more proton than the atom.
   C the ion has one more electron than the atom.
   D the ion has one fewer electrons than the atom. (2)

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LONG QUESTIONS

7. Draw Lewis diagrams for each of the following:
   7.1 SCl_2 (2)
   7.2 CS_2 (3)
   7.3 CH_4 (2)

8. 8.1 What is meant by an ionic bond? (2)
   8.2 Use suitable examples to explain the difference between covalent and ionic bonds. (6)

9. The following table summarises the properties of the various types of chemical bonds. Complete the table.

Type of bond	Electrons	Occurs between	Electrostatic forces between
Covalent			
Ionic			
Metallic			

(9)

10. Elements A, X and Z are in groups 16, 17 and 1 respectively.
   10.1 Write down the valence electron configuration for each of the elements. (6)
   10.2 Write down the chemical formula of the compound formed when:
      10.2.1 A reacts with Z.
      10.2.2 X reacts with Z.
      10.2.3 A reacts with X. (6)
   10.3 Write down the type of chemical bond that results when the above compounds (Questions 10.2.1, 10.2.2 and 10.2.3) are formed. (6)

ASSESSMENTS

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MARKING GUIDELINES

MULTIPLE CHOICE

1. C ✓ ✓ This the only ionic compound in the answers. Ionic compounds do not form molecules. [CL 2] (2)

2. C ✓ ✓ Fluorine atoms normally contain 9 electrons; atomic number is 9. This one has 10 electrons and still has the same number of protons. So, it is an anion. [CL 2] (2)

3. B ✓ ✓ Sodium is the only metal in the list and metals will give away electrons when forming ionic bonds. [CL 2] (2)

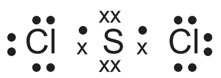
4. B ✓ ✓ A molecule of CO_2 has a double bond between the carbon atom and each oxygen atom> this means that there are 4 shared pairs of electrons. If answer D was chosen, remind the learner(s) that a shared pair contains two electrons. Two shared pairs have four electrons. If the question has asked "How many electrons are shared?" then D would have been the correct answer. [CL 3] (2)

5. A ✓ ✓ In a molecule of nitrogen there is a triple covalent bond between the atoms of nitrogen. So, electrons are shared and not transferred. The atoms are shared equally because they are attracted equally strongly by identical atoms. [CL 2] (2)

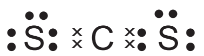
6. D ✓ ✓ The potassium atom has the same number of protons (and atomic number) as the ion because they are the same element. Potassium forms positive ions, so it must have lost an electron. [CL 3] (2)

LONG QUESTIONS

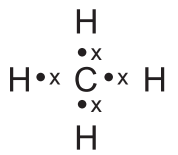
7.

a. 

✓ ✓ [CL 2] (2)

b. 

✓ ✓ ✓ [CL 3] (3)

c. 

✓ ✓ [CL 2] (2)

8. 8.1 An ionic bond is one which involves the transfer of electrons. ✓ ✓ [CL 1] (2)
Stress to learners that it is what happens with electrons that characterises a bond, not which two types of elements are actually bonded – this is only used to help us decide what type of bond occurs.

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8.2 Ionic bonds involve the transfer of electrons from a metal to a non-metal ✓ e.g. when potassium reacts with fluorine, a potassium atom transfers ✓ an electron to a fluorine atom, and each form an ion. ✓ Covalent bonding involves the sharing ✓ of electrons between two atoms, e.g. when two F atoms bond, the unpaired electron on each atom ✓ is shared between the atoms, so there is a shared pair of electrons. ✓ [CL 4] (6)
Any two suitable examples must be accepted.

9.

Type of bond	Electrons	Occurs between	Electrostatic forces between
Covalent	Shared ✓	Non-metal atoms ✓	Nuclei and other atom's electrons ✓
Ionic	Transferred ✓	Metal and non-metal ✓	Positive and negative ions ✓
Metallic	Delocalised ✓	Atoms of the same metal ✓	Positive metal ions and delocalised electrons ✓

[CL 2] (9)

10. 10.1 A $ns^2 np_x^2 np_y^1 np_z^1$ ✓ ✓
X $ns^2 np_x^2 np_y^2 np_z^1$ ✓ ✓
Z ns^1 ✓ ✓ [CL 3] (6)

10.2 10.1.1 Z_2A ✓ ✓
10.2.1 ZX ✓ ✓
10.2.3 AX_2 ✓ ✓ [CL 4] (6)

Z is given first in the first two formulae because it is a metal and the others are non-metals. A is written before X because A is further to the left than X.

10.3 1. Ionic (Z is a metal while A is a non-metal) ✓ ✓
2. Ionic (X is also a non-metal) ✓ ✓
3. Covalent (A and X are both non-metals) ✓ ✓ [CL 3] (6)

ASSESSMENTS

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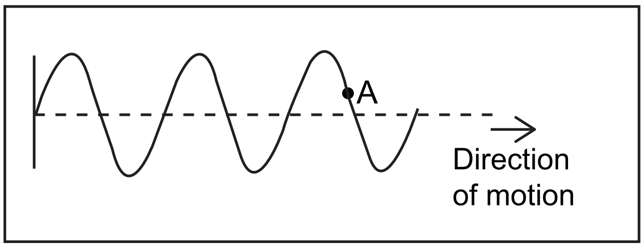
Topics 6 & 7: Transverse Pulses and Transverse Waves

QUESTIONS

MULTIPLE CHOICE

1. The transverse wave, shown in the diagram below, moves from left to right. In which direction is particle A moving?

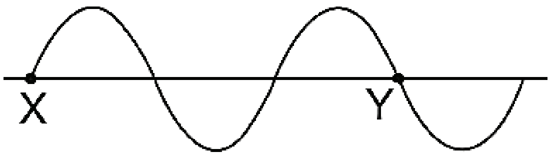


A up
B down
C left
D right (2)

2. The period of vibration of a source of waves in 25 s. What is its frequency (in Hz)?
A 0,04
B 0,40
C 2,50
D 25,00 (2)

3. A wave that carries a large amount of energy will always have a …
A large amplitude.
B small amplitude.
C high frequency.
D short wavelength. (2)

4. The diagram below shows two points **X** and **Y** on a wave train.



How many wavelengths separate **X** and **Y**?
A 0,75
B 1,00
C 1,50
D 3,00 (2)

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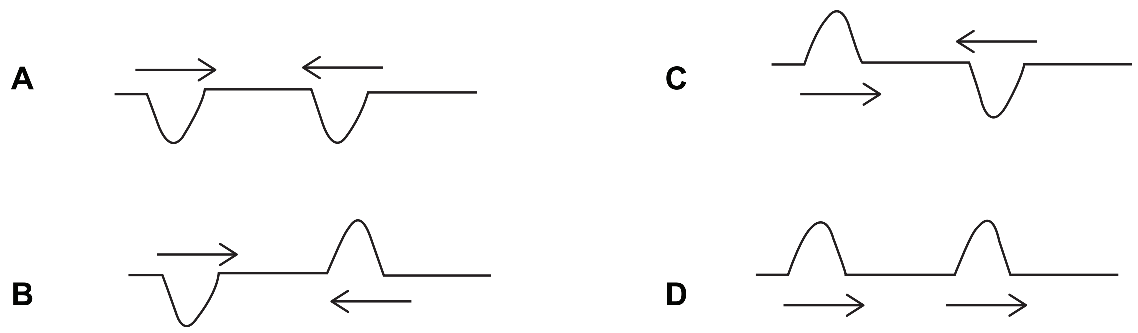
5. A ripple tank with a vibration hitting the surface of the water at a frequency of 50 Hz produces 5 complete waves in a distance of 10 cm. What is the velocity of the water waves that are produced?
   A 0,1 $m{\cdot}s^{-1}$
   B 10 $m{\cdot}s^{-1}$
   C 1,0 $m{\cdot}s^{-1}$
   D 100 $m{\cdot}s^{-1}$ (2)

6. What is the term used for the time taken by a wave to complete one vibration?
   A amplitude
   B wavelength
   C frequency
   D period (2)

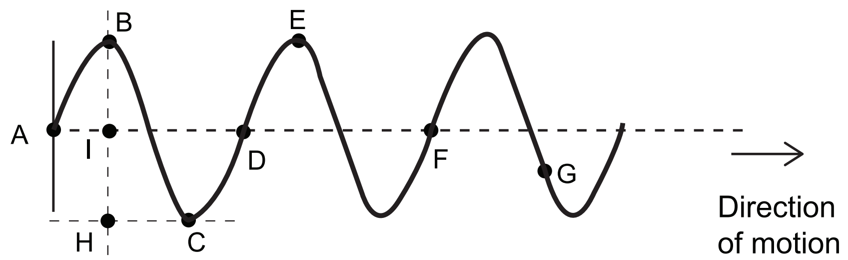
7. Which of the following diagrams best illustrates pulses which will interfere constructively when they meet up with each other?



(2)

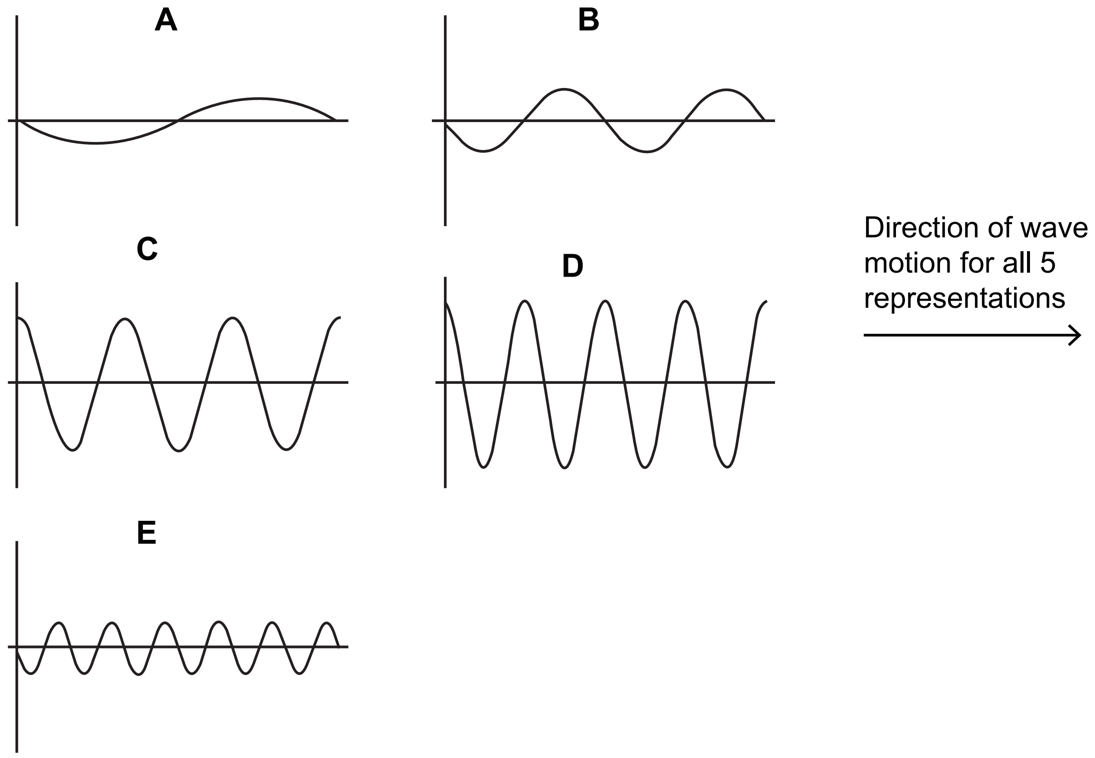
LONG QUESTIONS

8. Consider the following wave and answer the questions that follow.



8.1 Define a *transverse wave.* (2)
8.2 Distinguish between *a wave* and *a pulse.* (2)
8.3 With reference to the diagram of the wave shown above, write down the letters that indicate:
   8.3.1 amplitude
   8.3.2 one wavelength from position B
   8.3.3 a point that is exactly out of phase with point E
   8.3.4 two points that are in phase with point A (4)

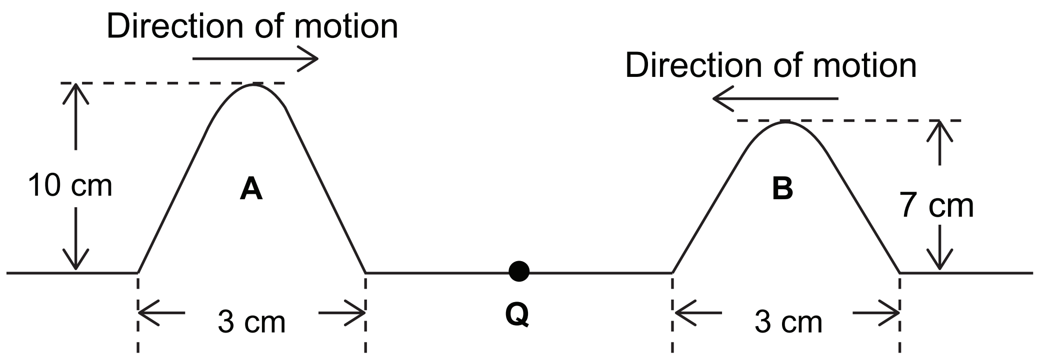
9. Refer to the graphs below when answering the questions that follow.
The x-axis represents time and the y-axis represents displacement. The scale on all the axes is the same in all five graphs.



9.1 Which graph represents the wave with the greatest amplitude? (2)
9.2 Which graph represents the wave with the greatest period? (2)
9.3 Which graph represents the wave with the greatest frequency? (2)

10. A boy sitting on a pier at the beach watches water waves passing beneath him. Nine crests pass beneath him in one minute.
10.1 Define *frequency*. (2)
10.2 How many complete waves pass under him in one minute? (1)
10.3 What is the frequency of the waves? (3)
10.4 What is the period of the waves? (3)

11. Two pulses, A and B, travelling along a string, approach each other. The amplitudes of the pulses are 10 cm and 7 cm respectively. They meet at point Q. Assume that no energy is lost.



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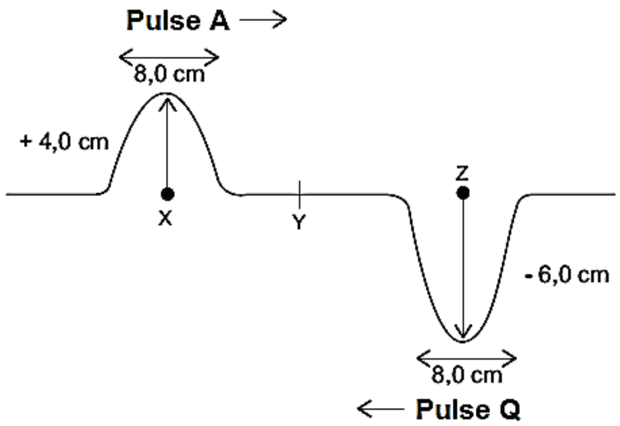
11.1 Define the term *pulse*. (2)
11.2 **Name** the phenomenon that occurs when **A** and **B** meet at point **Q**. (2)
11.3 State *the principle of superposition*. (2)
11.4 Draw a **sketch** to show the resulting pulse when **A** and **B** meet at point **Q**. Show all **relevant** measurements. (3)
11.5 What happens to pulse **B** AFTER pulse **A** and pulse **B** have met? Choose your answer from **ONE** of the following:
A moves to the right
B becomes stationary OR
C moves to the left (1)
11.6 Pulse **A** travels a distance of 60 m in 2 minutes. Calculate the speed of pulse **A**. (3)

12. Two pulses, **P** and **Q** travel along a string, and approach each other at the same speed. Both pulses have a pulse length of 8,0 cm. Pulse **P** has an amplitude of +4,0 cm when it is at position **X**. Pulse **Q** has an amplitude of –6 cm when it is at position **Z**. Points **X** and **Z** are the same distance from point **Y**. Pulse **P** and **Q** meet at position **Y**. Assume that no energy is lost.



12.1 Write down the name of the phenomenon that occurs when the two pulses meet at position **Y**. (2)
12.2 Make a labelled sketch to show what happens when the pulses **P** and **Q** meet at position **Y**. Also indicate the pulse length. (3)
12.3 Make a labelled sketch to show what happens when pulse **P** reaches position **Z**. (2)
12.4 Pulse **P** travels from position **X** to position **Z**, a distance of 6,0 cm, in 1,5 s. Calculate the speed of pulse **P**. (4)

ASSESSMENTS

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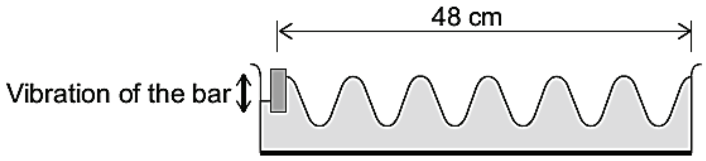
13. Water waves can be made by vibrating a wooden bar up and down in a tray of water. The bar moves up and down at a frequency of 5 Hz.



13.1 How many complete waves are there in 48 cm? (2)
13.2 Are the water waves longitudinal or transverse? Explain briefly. (3)
13.3 Calculate the period of the waves. (3)
13.4 Calculate the speed of the water waves. (4)

14. A transverse wave of frequency 250 Hz travels at the speed of 1 500 $m \cdot s^{-1}$.
14.1 Define *a transverse wave*, (2)
14.2 Define *frequency*. (2)
14.3 Calculate the period of these waves. (3)
14.4 Define *wavelength*. (2)
14.5 Calculate the wavelength of the waves. (3)

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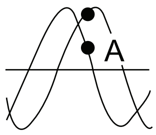
MARKING GUIDELINES

MULTIPLE CHOICE

1. A✓ ✓



The diagram shows that when the wave moves on, point A moves up [CL4] (2)

2. A✓ ✓ $f = \frac{1}{1} = \frac{1}{25} = 0{,}04$ Hz. [CL2] (2)

3. A✓ ✓ The amplitude of a wave depends on the amount of energy of the vibrating source. The greater the amount of energy in the vibration, the greater the amplitude of the wave. [CL2] (2)

4. C✓ ✓ The diagram shows two complete waves. Points X and Y are separated by 1½ wavelengths (1,5 wavelengths). [CL2] (2)

5. C✓ ✓ $\lambda = \frac{0{,}10}{5} = 0{,}02$ m

   $v = f\lambda = 50 \times 0{,}02 = 1{,}0$ m·s^{-1} [CL2] (2)

6. D✓ ✓ The period of a wave is the time taken for one complete vibration. [CL1] (2)

7. A✓ ✓ Both options B and C will interfere destructively when they meet each other. Option D shows two pulses moving in the same direction along the string. They will continue to move at the same speed, and will never meet up with each other, so they cannot interfere constructively. Therefore, only option A shows pulses which will interfere constructively. [CL3] (2)

LONG QUESTIONS

8.1 A *transverse wave* is a regular repeated disturbance ✓ that travels at right angles to the direction of disturbance. ✓ [CL1] (2)

8.2 A *pulse* is a single disturbance✓ whereas a *wave* is a series of disturbances. ✓ [CL1] (2)

8.3 a) BI or HI ✓
b) BE (or E) ✓
c) C ✓
d) D and F ✓ [CL1] (4)

9.1 D ✓ ✓ [CL2] (2)
9.2 A ✓ ✓ [CL1] (2)
9.3 E ✓ ✓ [CL1] (2)

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10.1 The *frequency* (of a vibration) is the number of vibrations per unit time. ✓ ✓ [CL1] (2)

10.2 8 ✓ complete waves [CL1] (1)

10.3 $f = \frac{\text{number of waves}}{\text{time}}$ ✓ (method)

$= \frac{8}{60}$ ✓ (substitutions)

$= 0{,}13\ \text{Hz}$ ✓ (accuracy; SI units) [CL2] (3)

10.4 $T = \frac{1}{f}$ ✓ (method)

$= \frac{1}{0{,}13}$ ✓ (substitutions)

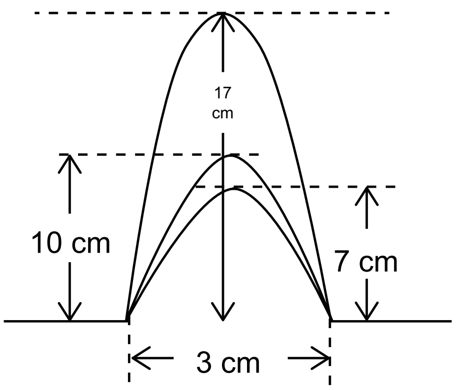
$= 7{,}5\ \text{s}$ ✓ (accuracy; SI units) [CL2] (3)

11.1 A *pulse* is a single disturbance. ✓ ✓ [CL1] (2)

11.2 Constructive ✓ interference ✓ [CL2] (2)

11.3 The amplitude of the resultant pulse ✓ (wave) is the algebraic sum of their individual
amplitudes. ✓ [CL1] (2)

11.4



✓ Amplitude = 17 cm

✓ Same pulse width

✓ Shape of pulse

[CL3] (3)

11.5 C (It continues moving in its original direction) ✓ [CL3] (1)

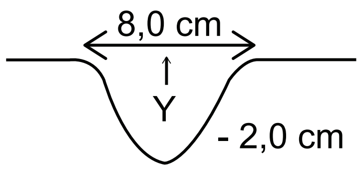
11.6 $v = \frac{\text{distance}}{\text{time}}$ ✓ (method)

$= \frac{60}{2 \times 60}$ ✓ (conversion of minutes to seconds; substitutions)

$= 0{,}5\ \text{m·s}^{-1}$ ✓ (accuracy; SI units) [CL2] (3)

12.1 destructive ✓ interference ✓ [CL2] (2)

12.2

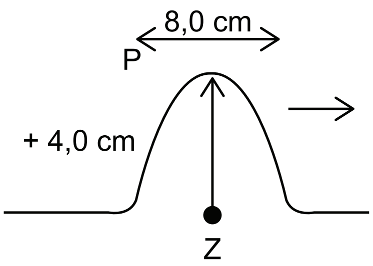


✓ pulse length = 8,0 cm

✓ amplitude of pulse = -2,0 cm

✓ shape of pulse [CL2] (3)

12.3



✓ Same size (pulse length and amplitude)

✓ Same shape [CL2] (2)

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12.4 $v = \frac{\text{distance}}{\text{time}}$ ✓ (method)

$= \frac{0,06✓}{1,5}$ ✓ (conversion of cm to m; substitutions)

$= 0,4\ \text{m·s}^{-1}$ ✓ (accuracy; SI units) [CL2] (4)

13.1 6 ✓ ✓ [CL2] (2)

13.2 Transverse ✓ The direction of disturbance is perpendicular to the direction of propagation. ✓ ✓ [CL2] (3)

13.3 $T = \frac{1}{f}$ ✓ (method)

$= \frac{1}{5}$ ✓ (substitution)

$= 0,2\ \text{s}$ ✓ (accuracy; SI units) [CL2] (3)

13.4 $v = \frac{\text{distance}}{\text{time}}$ ✓ (method)

$= \frac{0,48✓}{6 \times 0,2}$ ✓ (conversion of cm to m)

(using 6 x period for 6 waves)

$= 0,4\ \text{m·s}^{-1}$ ✓

(accuracy; SI units) [CL3] (4)

14.1 A series of pulses (a regularly repeated vibration) ✓ where the disturbance is at right angles to the direction in which the wave travels. ✓ [CL1] (2)

14.2 *Frequency* is the number of vibrations (waves) per unit time. ✓ ✓ [CL1] (2)

14.3 $T = \frac{1}{f}$ ✓ (method)

$= \frac{1}{250}$ ✓ (substitutions)

$= 0,004\ \text{s}$ ✓ (accuracy; SI units) [CL2] (3)

14.4 *Wavelength* is the displacement between two consecutive points on a wave which are in phase. ✓ ✓ [CL1] (2)

14.5 $v = f\lambda$ ✓ (method)

$1\,500 = 250\,\lambda$ ✓ (substitutions)

$\lambda = 6\ \text{m·s}^{-1}$ ✓ (accuracy; SI units) [CL2] (3)

ASSESSMENTS

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Topics 8 & 9: Longitudinal Waves and Sound

QUESTIONS

MULTIPLE CHOICE

1. Which ONE of the following will sound not travel through?
   A air
   B water
   C steel
   D a vacuum (2)

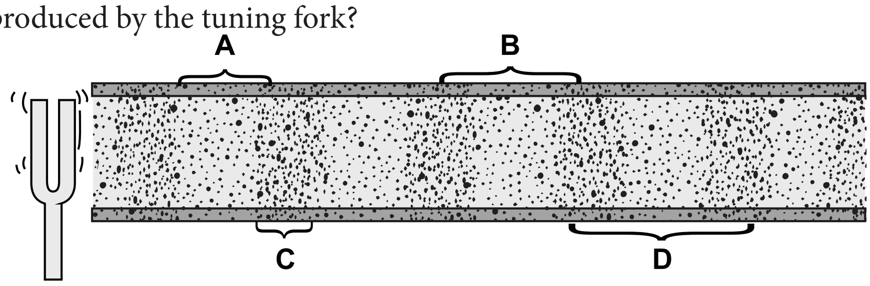
2. Compressions and rarefactions are characteristic of …
   A longitudinal waves.
   B transverse wave.
   C both of these.
   D neither of these. (2)

3. Through which of the following media do sound waves travel the fastest?
   A air
   B water
   C steel
   D a vacuum (2)

4. The loudness of a musical sound is a measure of the sound wave's …
   A wavelength.
   B frequency.
   C speed.
   D amplitude. (2)

5. The pitch of a musical sound depends on the sound wave's …
   A wavelength.
   B frequency.
   C speed.
   D amplitude. (2)

6. Which letter, A, B, C or D, correctly shows one wavelength of the sound wave produced by the tuning fork?



(2)

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LONG QUESTIONS

7.1 How is sound produced? (2)

7.2 The speed of sound in helium is three times as fast as the speed of sound in air. A tuning fork sends out a note with a frequency of 450 Hz.

 7.2.1 Explain why the frequency of the note does not change when it travels from air into helium. (2)

 7.2.2 Explain what happens to the wavelength of the note when it travels from air into helium. (3)

7.3 A pulse of sound is sent vertically downwards from a ship to the seabed below. The pulse takes 0,28 s to return to the ship. The speed of sound in water is 1 500 $m·s^{-1}$. Calculate the depth of the water at that point. (4)

7.4 Bats can emit and hear sounds up to a maximum of $1,2 \times 10^5$ Hz, while dolphins can emit and hear sounds of up to a maximum $2,0 \times 10^5$ Hz. The speed of sound in air is 340 $m·s^{-1}$ and in water sound travels at 1 500 $m·s^{-1}$.

 7.4.1 Calculate the minimum wavelength of sounds that bats can hear in air. (3)

 7.4.2 Calculate the minimum wavelength of sounds that dolphins can hear in water. (3)

 7.4.3 Why do you think dolphins use higher frequencies than bats? (2)

7.5 You can tell how far away a thunderstorm is by measuring the time between a flash of lightning and hearing the clap of thunder. If the storm is 1 km away from you, you will see the flash of lightning 3 s before you hear the clap of thunder. [The speed of sound in air is 330 $m·s^{-1}$ and the speed of light is 3×10^8 $m·s^{-1}$]

 7.5.1 Explain why you see a flash of lightning and then 3 s later you hear the thunder. (2)

 7.5.2 If the time gap between seeing the lightning and hearing the thunder is 8 s, how far away is the storm? (2)

7.6 You put one ear against the railing of a steel fence. You hear your friend tap the fence loudly with a stick from some distance away.

 7.6.1 Explain why you will hear two taps when your friend taps the fence. (2)

 7.6.2 Which tap will you hear first? (1)

ASSESSMENTS

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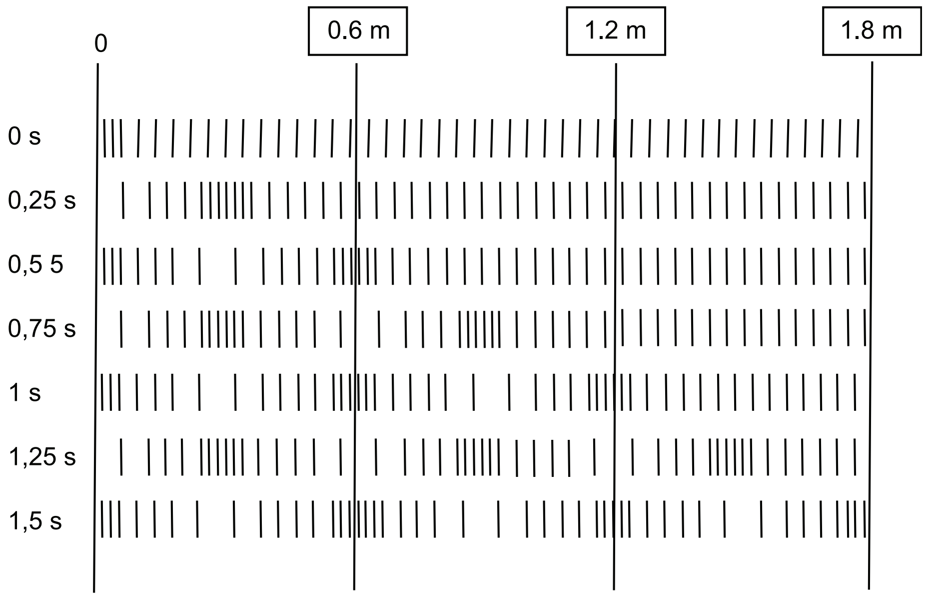
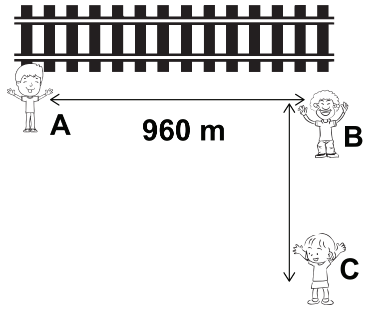
8. The diagram below shows a series of compressions and rarefactions travelling through a slinky spring. The position of the compressions and rarefactions is shown every $0,25\,s$. Study the diagram and answer the questions that follow:



8.1 Explain what is a rarefaction? (2)
8.2 Determine the period of this wave. (2)
8.3 Determine the wavelength of the wave. (2)
8.4 How far did the first compression travel in 1,5 s? (1)
8.5 Calculate the speed of this wave. (3)
[This question has been adapted from the Mind Action Series: Grade 10 Physical Sciences Textbook and Workbook]

9. Two boys, A and B, find an old railway track that is no longer in use. A and B stand 960 m from each other next to the railway track, as shown in the sketch.
A puts his ear against the rail, while B hits the track with a stone. A girl, C, is curious about what the boys are doing, and watches from point C in the sketch.
The speed of sound through iron is 5 280 $m \cdot s^{-1}$ and the speed of sound through air is 340 $m \cdot s^{-1}$.



9.1 Calculate how long it takes before A hears the sound once B hits the track. (3)
9.2 Calculate how far C must stand from B to hear the sound at precisely the same time as A. (3)

10. A salvage ship sends a SONAR signal to the bottom of the ocean to determine the depth of the seabed. A return signal is received 3 s later. The speed of sound in sea water is 1 450 $m \cdot s^{-1}$.
10.1 What phenomenon causes the signal to return from the bottom of the ocean? (1)

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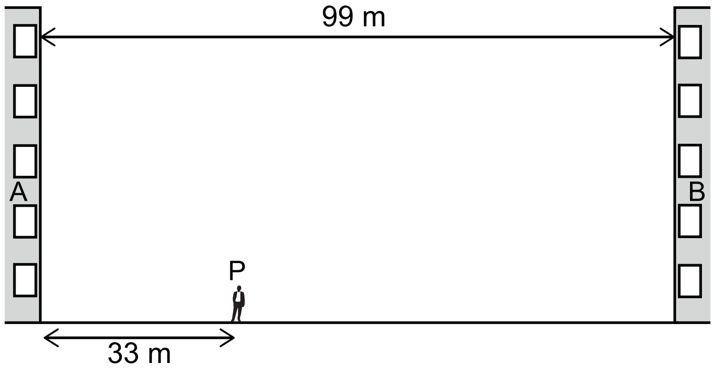
10.2 Calculate the depth of the ocean at that point. (4)

10.3 At what frequency must the sound be generated if its wavelength in water is 50 mm? (3)

11. A boy stands between two tall buildings which are 99 m apart from one another. He stands 33 m from Building A, as shown in the diagram below.



He claps his hands once, and hears several echoes.
The speed of sound in air is 330 m·s^{-1}.

11.1 Explain how an echo originates. (2)

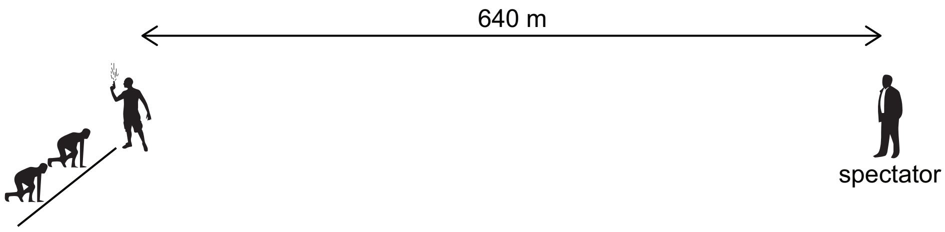
11.2 Calculate the time between clapping his hands and hearing

11.2.1 the first echo. (3)

11.2.2 the third echo. (3)

12. Bats emit pulses of high frequency sound waves (ultrasound) which reflect off obstacles and objects in their surroundings. By detecting the time delay between the emitted pulse and the return of the reflected pulse, the bat can determine the location of the object. How long would it take for a pulse to be sent by a bat to an object which is 12,5 m away from it. The speed of sound in air is 245 m·s^{-1}. (4)

13. A man holds a starting pistol at the start of a 100 m race. A spectator standing 640 m away from the starting pistol sees the flash and hears the sound 2 s later.



Use this information to determine the speed of sound in air. (4)

ASSESSMENTS

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MARKING GUIDELINES

MULTIPLE CHOICE

1. D✓ ✓ Sound waves are longitudinal waves which require a medium for their propagation. There are no atoms (is no material/medium) in a vacuum. [CL 1] (2)

2. A✓ ✓ Longitudinal waves consist of rarefactions and compressions because they are pressure waves. [CL 1] (2)

3. C✓ ✓ The vibrations of sound waves are transferred more quickly from one particle to another in solids, and in this case in steel. [CL 2] (2)

4. D✓ ✓ Loudness is related to the energy (intensity) of the sound wave. Intensity of a wave is related to its amplitude. [CL 2] (2)

5. B✓ ✓ The pitch (tone) of a musical sound is related to its frequency. [CL 2] (2)

6. B✓ ✓ The wavelength of a longitudinal wave is measured from the centre of one compression to the centre of the next successive compression. [CL 2] (2)

LONG QUESTIONS

7.1 Sound is produced by a vibrating object.✓ The vibrations of the object sets up longitudinal (pressure) waves✓ which transport sound energy. [CL1] (2)

7.2 7.2.1 The frequency of the note is determined by the frequency of the vibrating object.✓ It does not change as the sound passes from one medium to another.✓ [CL2] (2)

7.2.2 The speed of sound in helium is three times faster than it is in air, but the frequency remains constant.

$v_{\text{air}} = f\lambda_{\text{air}}$ $\quad$ $v_{\text{helium}} = 3 \times v_{\text{air}}$✓$= f\lambda_{\text{helium}}$✓

The wavelength of the note in helium is three times as long as the wavelength of the sound in air. ✓ (3)

7.3 Distance travelled by pulse $= v \times t$ ✓ (method)

$= 1\,500 \times 0,28$✓ (substitutions)

$= 420\ \text{m}$

Distance to seabed $= \frac{1}{2} \times 420$✓ (method)

$= 210\ \text{m}$✓ (accuracy; SI units) [CL2] (4)

7.4 7.4.1 $v = f\lambda$✓ (method)

$340 = 1,2 \times 10^5 \lambda$✓ (substitutions)

$\lambda = 2,83 \times 10^{-3}\ \text{m}\ (0,0028\ \text{m})$✓ (accuracy; SI units) [CL2] (3)

7.4.2 $v = f\lambda$✓ (method)

$1\,500 = 2,0 \times 10^5\ \lambda$✓ (substitutions)

$\lambda = 7,5 \times 10^{-3}\text{m}\ (0,0075\ \text{m})$✓ (accuracy; SI units) [CL2] (3)

7.4.3 Bats emit higher frequencies because the speed of sound in water is five times greater than the speed of sound in air. ✓ If the frequency was lower,

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the wavelength would become very much longer. ✓ (And if the wavelength was too long the bats would not be able to "see" smaller objects.) [CL3] (2)

7.5 7.5.1 Both events (the flash of lightning and the clap of thunder) occur at the same time. ✓ The light wave and the sound wave travel through the air at different speeds, therefore light, which travels faster than sound will be seen first, and thunder will be heard later. ✓ [CL3] (2)

7.5.2 For a distance of 1 000 m, the time gap is 3 s.
If the time gap is 8 s, the distance $= \frac{8 \times 1\,000}{3}$ ✓
$= 2\,667$ m (2,67 km) ✓ [CL3] (2)

7.6 7.6.1 One sound will come to you through the air ✓ and the other will come through the steel fence. ✓ [CL2] (2)

7.6.1 The tap that travels through the fence (steel). ✓ [CL2] (1)

8.1 A rarefaction is a position on a longitudinal wave ✓ where the particles are widely spaced from one another. ✓ [CL1] (2)

8.2 0,5 s ✓ ✓ (One complete wavelength is generated at 0,5 s – from the middle of one compression to the middle of the next successive compression.) [CL3] (2)

8.3 0,6 m ✓ ✓ [CL3] (2)

8.4 1,8 m ✓ ✓ [CL3] (1)

8.5 $v = \frac{\text{distance}}{\text{time}}$ ✓ (method)
$= \frac{1,8}{1,5}$ ✓ or $\frac{0,6}{0,5}$ (substitutions)
$= 1,2\ \text{m·s}^{-1}$ ✓ (accuracy; SI units) [CL3] (3)

9.1 $v = \frac{\text{distance}}{\text{time}}$ ✓ (method)
$5\,280 = \frac{960}{\text{time}}$ ✓ (substitutions)
$\text{Time} = 0,18\ \text{s}$ ✓ (accuracy; SI units) [CL2] (3)

9.2 $v = \frac{\text{distance}}{\text{time}}$ ✓ (method)
$340 = \frac{\text{distance}}{0,18}$ ✓ (substitutions)
$\text{Distance} = 61,2\ \text{m}$ ✓ (accuracy; SI units) [CL2] (3)

10.1 Reflection ✓ (or an echo ✓) [CL1] (1)

10.2 $v = \frac{\text{distance}}{\text{time}}$ ✓ (method)
$1\,450 = \frac{\text{distance}}{3}$ ✓ (substitutions)
$\text{Distance} = 4\,350\ \text{m}$ ✓
The seabed is $\frac{1}{2}$ of this distance $= \frac{1}{2} \times 4\,350$✓$= 2\,175$ m✓ [CL2] (4)

10.3 $v = f\lambda$ ✓ (method)
$1\,450 = f \times 0,05$ ✓ (substitutions)
$f = 29\,000$ Hz ✓ (accuracy; SI units) [CL2] (3)

ASSESSMENTS

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11.1 If the delay between making the sound and its reflection is sufficient for a person to hear two separate sounds, ✓ the reflection of the sound ✓ from the surroundings (walls) is an echo. [CL2] (2)

11.2 11.2.1 The first echo comes from the closest wall (Building A).

$\text{Distance} = \text{speed} \times \text{time}$ ✓ (method)

$66 = 330 \times \text{time}$ ✓ (substitutions)

$\text{Time} = 0{,}2\ \text{s}$ ✓ (accuracy; SI units) [CL3] (3)

11.2.2 The second echo comes from Building B.

$\text{Distance} = 2 \times 66$

Therefore $\text{time} = 0{,}4\ \text{s}$

The third echo comes from the sound reflecting off Building B then Building A and back to the man.

$\text{Distance} = 66 + 99 + 33 = 198\ \text{m}$ ✓ (method)

$\text{Time} = \frac{198}{330}$ ✓ (substitutions)

$= 0{,}6\ \text{s}$ ✓ (accuracy; SI units) [CL4] (3)

12. $\text{Distance} = \text{speed} \times \text{time}$ ✓ (method)

$2 \times 12{,}5$✓ $= 245 \times \text{time}$ ✓ (substitutions)

$\text{Time} = 0{,}10\ \text{s}$ ✓ (accuracy; SI units) [CL2] (4)

13. $v = \frac{\text{distance}}{\text{time}}$ ✓ (method)

$= \frac{640✓}{2}$ ✓ (substitutions)

$= 320\ \text{m·s}^{-1}$ ✓ (accuracy; SI units) [CL2] (4)

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Topic 10: Electromagnetic Radiation

QUESTIONS

MULTIPLE CHOICE

1. SABC broadcasts radio waves from its various stations. What type of wave does the radio wave transmitter send out?
   A a longitudinal wave
   B a sound wave
   C a mechanical wave
   D a transverse wave (2)

2. The electromagnetic waves with the lowest energy are …
   A X-rays.
   B microwaves.
   C gamma rays.
   D radio waves. (2)

3. Electromagnetic waves can travel through …
   A a medium.
   B a vacuum.
   C a medium and/or a vacuum.
   D a vacuum and/or air only. (2)

4. Compared to ultraviolet waves, the wavelength of infrared waves is …..
   A shorter.
   B longer.
   C the same.
   D slower. (2)

5. Electromagnetic waves consist of ……
   A compressions and rarefactions of electric and magnetic fields.
   B electric and magnetic fields that vibrate at $90°$ to each other.
   C charged particles of light energy, called photons.
   D high-frequency gravitational waves. (2)

LONG QUESTIONS

6. Microwaves are one type of electromagnetic radiation.

6.1 Name another type of electromagnetic radiation which has a lower frequency than microwaves. (1)

6.2 What do all types of electromagnetic radiation transfer from one place to another? (1)

ASSESSMENTS

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6.3 A mobile phone network uses microwaves to transmit signals through the air. The microwaves have a frequency of $1,8 \times 10^{9}$ Hz and travel at a speed of $3,0 \times 10^{8}$ m·s^{-1}. Calculate the wavelength of the microwaves. (3)

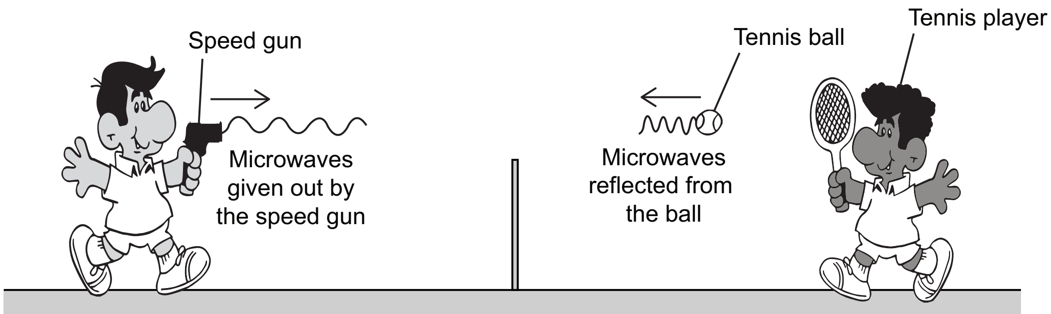
6.4 Some scientists suggest there is a possible link between using a mobile phone and male fertility. The results of their study are given in the table below.

Mobile phone use in hours per day	Sperm count in millions of sperm cells per cm³ of semen
0	86
less than 2	69
2 – 4	59
more than 4	50

The results show a negative correlation: the more hours a mobile phone is used each day, the lower the sperm count. However, the results do not necessarily mean using a mobile phone causes the reduced sperm count.
Explain why these results do not <u>necessarily</u> show that a lower sperm count is <u>caused</u> by the use of a mobile phone. (2)

6.5 Give ONE other use of microwaves. (1)

7. The diagram below shows a tennis coach using a "speed gun" to measure how fast the player serves the ball.



The microwaves transmitted by the speed gun have a frequency of 24 000 000 000 Hz.

7.1 Calculate the wavelength of the microwaves emitted from the speed gun. (3)

7.2 Some of the microwaves emitted are absorbed by the tennis ball. What effect will these absorbed waves have on the tennis ball? (1)

7.3 Some of the microwaves emitted are reflected by the moving tennis ball. There is an apparent change in the frequency of the microwaves when they are received by the speed gun. The speed gun calculates the difference in the frequency and using this information it can estimate the speed of the tennis ball. The graph, shown on the next page, shows the relationship between the difference in frequency and the speed of the tennis ball.

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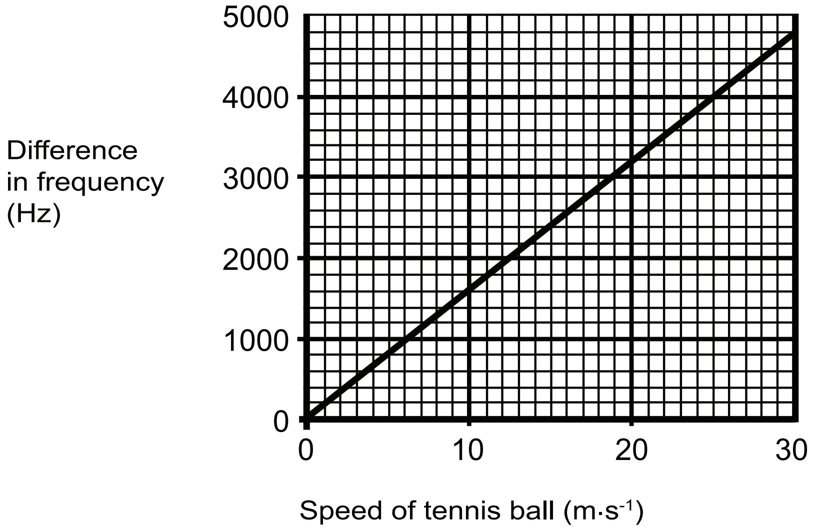
Graph of difference in frequency against speed of the tennis ball



Describe the relationship between the difference in frequency and the speed of the tennis ball. (2)

7.4 When the difference in frequency is 3 200 Hz, what is the speed of the tennis ball? (2)

8. In 1969 Neil Armstrong was the first man to walk on the Moon. He spoke to the mission control centre in Houston, USA, using a radio telephone. He also kept in contact via radio telephone with his fellow astronaut, Buzz Aldrin, while they walked on the Moon's surface. The conditions on the Moon do not support life. There is no air, and therefore no oxygen, and no clouds in the lunar sky. The astronauts wore spacesuits to maintain a comfortable temperature and pressure on their bodies, and to protect them from high energy electromagnetic radiation, such as ultraviolet, X-rays and gamma rays.

8.1 The radio frequency which Neil Armstrong used to contact Earth was 2 287,5 MHz. Calculate:

8.1.1 the wavelength of the radio waves (in m). (4)

8.1.1 the time (in s) it took for the radio signal to reach the Earth, given that the distance of the Moon from the Earth is $3,84 \times 10^8$ m. (3)

8.2 Explain why sound cannot be transmitted on the Moon. (2)

8.3 Gamma rays are the highest energy form of electromagnetic radiation. Explain why it is dangerous for living cells to be exposed to gamma radiation. (2)

9. The diagram below shows some regions of the electromagnetic spectrum.

gamma rays	X-rays	ultra-violet	visible light			radio waves

9.1 In the correct order, from left to right, name the two "unnamed" regions. (2)

9.2 Describe TWO properties which all electromagnetic waves have in common. (2)

9.3 Describe the relationship between the energy of the radiation and its frequency. (2)

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9.4 Calculate the energy of a photon of visible light with a wavelength of 680 nm.
$1\text{nm} = 1 \times 10^{9}\,\text{m}$. (6)

9.5 X-rays are used to diagnose bone fractures as well as to investigate how the lungs are able to function. Ultrasound is used to diagnose conditions of the internal organs, for example, the kidneys, liver, and the development of the foetus during pregnancy.

9.51 Give TWO differences between ultrasound and X-rays. (2)

9.5.2 Why is ultrasound safe to use as a tool to investigate the development of the foetus during pregnancy, but X-rays are not? (2)

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MARKING GUIDELINES

MULTIPLE CHOICE

1. D✓ ✓ Electromagnetic waves are transverse EM waves. [CL 3] (2)
2. D✓ ✓ Radio waves have the lowest frequency (longest wavelength) therefore they have the lowest energy ($E = hf$). [CL 2] (2)
3. C✓ ✓ Light is an electromagnetic wave. It travels through glass, water and other transparent substances, as well as through air, and through Space, which is mostly a vacuum. [CL 4] (2)
4. B✓ ✓ Infrared waves have lower energy than ultraviolet waves, therefore they have lower frequencies and longer wavelengths. [CL 3] (2)
5. B✓ ✓ All the other options are false.

   A refers to longitudinal waves eg sound waves, and the idea of electric and magnetic fields is just a distractor.

   C is incorrect because the particles of "light" energy (photons or quanta) are not charged particles.
   D Gravitational waves are not electromagnetic waves. [CL 4] (2)

LONG QUESTIONS

6.1 Radio waves ✓ [CL1] (1)
6.2 Energy ✓ [CL1] (1)
6.3 $v = f\lambda$ ✓ (method)
$3 \times 10^8 = 1,8 \times 10^9 \lambda$ ✓ (substitutions)
$\lambda = \frac{3 \times 10^8}{1,8 \times 10^9}$
$= 0,17$ m ✓ (accuracy; SI units) [CL2] (3)
6.4 The sperm count can depend on many other factors ✓ as well as on the use of the mobile phone per day. We haven't sufficient detail to be able to come to an informed conclusion. (We need to know which other factors were controlled or had an impact on these results,) ✓ [CL4] (2)
6.5 Microwaves are used for cooking (eg in microwave ovens). They are used in speed traps.
ANY VALID application. ✓ [CL1] (1)
7.1 $v = f\lambda$ ✓ (method)
$3 \times 10^8 = 24\ 000\ 000\ 000\ \lambda$ ✓ (substitutions)
$\lambda = \frac{3 \times 10^8}{24 \times 10^9}$
$= 0,0125$ m $(0,013$ m$)$ ✓ (accuracy; SI units) [CL2] (3)
7.2 The temperature of the tennis ball will increase. ✓ [CL3] (1)

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7.3 The difference in frequency is directly proportional ✓ to the speed of the ball. ✓ [CL3] (2)

7.4 20✓m·s^{-1} ✓ [CL2] (2)

8.1 8.1.1 $v = f\lambda$ ✓ (method)

$3 \times 10^8 = 2\,287,5 \times 10^6 \lambda$ ✓ (conversion of MHz to Hz; substitutions)

$\lambda = \frac{3 \times 10^8}{2\,287,5 \times 10^6}$

$= 5,46 \times 10^{-4}$ m ✓ (accuracy; SI units) [CL3] (4)

8.1.2 $v = \frac{\text{distance}}{\text{time}}$ ✓ (method)

$3 \times 10^8 = \frac{3,84 \times 10^8}{\text{time}}$ ✓ (substitutions)

$\text{Time} = \frac{3,84 \times 10^8}{3 \times 10^8} = 1,28$ s ✓ (accuracy; SI units) [CL2] (3)

8.2 Sound is a longitudinal (mechanical) wave. ✓ It requires a medium to propagate; there is no air on the Moon therefore sound waves do not exist (travel) on the Moon. ✓ [CL3] (2)

8.3 High energy radiation is ionising radiation. ✓ It can (permanently) damage the cells (atoms, molecule) of living tissue. ✓ [CL2] (2)

9.1 infrared ✓ microwaves ✓ [CL1] (2)

9.2 They travel at the same speed in a vacuum. ✓
They consist of vibrating electric and magnetic fields (at 90° to each other). ✓ [CL1] (2)

9.3 The energy (of the radiation) is directly proportional to its frequency. ✓ ✓ [CL3] (2)

9.4 $v = f\lambda$ ✓ (method)

$3 \times 10^8 = f(680 \times 10^{-9})$ ✓ (substitutions; conversion)

$f = \frac{3 \times 10^8}{680 \times 10^{-9}}$

$= 4,41 \times 10^{14}$ Hz ✓ (accuracy)

$E = hf$ ✓ (method)

$= 6,62 \times 10^{-34} \times 4,41 \times 10^{14}$ ✓ (substitutions)

$= 2,92 \times 10^{-19}$ J ✓ (accuracy; SI units) [CL3] (6)

9.5 9.5.1 Ultrasound is a longitudinal wave; X-rays are transverse waves.
Ultrasound waves travel at lower speed than X-rays.
Ultrasound waves do not damage soft tissue; X-rays damage living tissue.
Ultrasound waves transfer less energy than X-rays.
ANY TWO valid differences. ✓ One mark for each. [CL3] (2)

9.5.2 Ultrasound waves do not damage soft tissue; X-rays damage living tissue.
OR Ultrasound waves transfer less energy than X-rays.
OR X-rays is a form of ionising radiation; ultrasound does not cause ionisation in the materials that it travels through. ✓ ✓ [CL3] (2)

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