# PHYSICAL SCIENCES

# Grade 11

# TERM 3

# RESOURCE PACK

# Contents

# WORKSHEETS

# Topic 9: Electrostatics

## WORKSHEET

### MULTIPLE CHOICE

**1.** Two identical small metal spheres on insulated stands carry equal charges and are a distance ***d*** apart. Each sphere experiences an electrostatic force of magnitude F.

The spheres are now placed a distance ½***d*** apart.

The magnitude of the electrostatic force each sphere now experiences is:

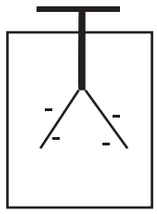
**A** ½F

**B** F

**C** 2F

**D** 4F (2)

**2.** The leaves on an electroscope are negatively charged as shown.



When an object is brought near it, the leaves begin to rise more. What can be concluded about the object from this observation?

**A** It is negatively charged.

**B** It is positively charged.

**C** It is neutral.

**D** No conclusion can be drawn from this experiment. (2)

**3.** Two charged objects on insulated stands have charges of **3Q** and **5Q** respectively. The objects are a distance **R** apart and exert a force **F** on each other. They are moved so that they are now $\frac{1}{3}$**R** apart. What is the new force that they exert on each other?

**A** **F**

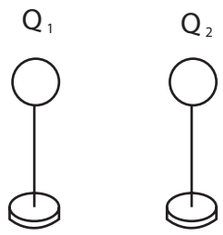
**B** $\frac{1}{3}$**F**

**C** 3**F**

**D** 9**F** (2)

## LONG QUESTIONS

**4.** Two metal spheres $Q_1$ and $Q_2$ on insulated stands, carry charges of +4 nC and −12 nC respectively.




**4.1** Using free body diagrams, show the electrostatic force on each sphere. (2)

**4.2** State the Principle of conservation of charge. (2)

The two spheres are now brought together to touch each other. They are then placed back in their original positions.

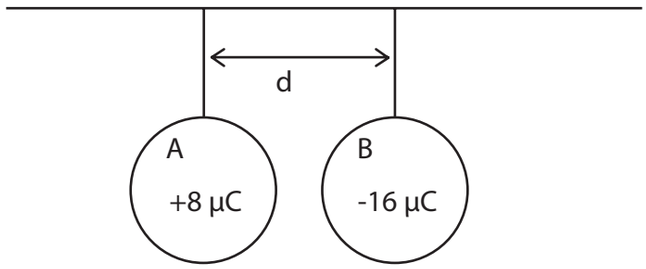
**4.3** Calculate the new charge on each sphere. (3)

**4.4** What quantity of charge is transferred between the two spheres during contact? (2)

When the spheres are moved closer together to touch, a small "spark" is seen to jump between the spheres when they are 2 mm apart. It takes 3 μs for the spark to jump between the spheres.

**4.5** Use the information above and your answer to **4.4** to calculate the current that passes from one sphere to the other. (Hint: Use $I = Q/t$) (4)

**5.** Two identical metal spheres, **A** and **B** have charges of +8 μC and -16 μC respectively. They are suspended from a horizontal wooden pole and placed a distance *d* apart from each other, as shown below.



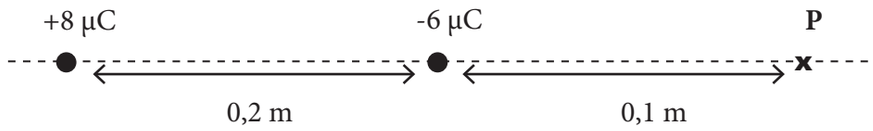

**5.1** Sphere **B** experiences an electrostatic force. In which direction does the force act? (1)

**5.2** The spheres are touched together and then separated and placed the same distance *d* apart from each other.

**5.2.1** When they touched each other, were electrons removed from or added to **A**? Give a reason for your answer. (2)

**5.2.2** Sphere **B** now experiences a force of 1,6 N. Calculate the distance *d*. (3)

**6.** Charges of +8 μC and -6 μC are placed 0,2 m apart as shown in the diagram. Point **P** is located 0,1 m to the right of the -6 μC charge and in line with both charges.




**6.1** Calculate the net electric field at point **P**. (5)

**6.2** Calculate the charge on an object placed at **P**, that experiences a force of $7{,}36 \times 10^{-13}$ N. (2)

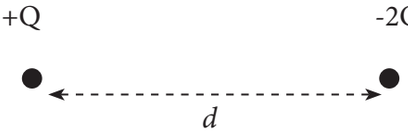
## CONSOLIDATION EXERCISE

**[38 MARKS]**

### MULTIPLE CHOICE

**1.** The diagram shows two particles with their centres placed a distance *d* apart. One particle has charge of +Q and the other a charge of –2Q. The two particles exert an electrostatic force of attraction, *F*, on each other. Each particle is now given an additional charge +Q and their separation is increased to a distance 2*d*.

Which one of the following gives the force that one particle exerts on the other?




**A** An attractive force of $\frac{F}{4}$

**B** A repulsive force of $\frac{F}{4}$

**C** An attractive force of $\frac{F}{2}$

**D** A repulsive force of $\frac{F}{2}$ (2)

**2.** Two identical conducting spheres X and Y carry charges of $+3{,}2 \times 10^{-19}$ C and $-6{,}4 \times 10^{-19}$ C respectively. The spheres are allowed to touch. How many electrons does sphere X gain while the spheres are touching each other?

**A** 6 electrons

**B** 3 electrons

**C** 2 electrons

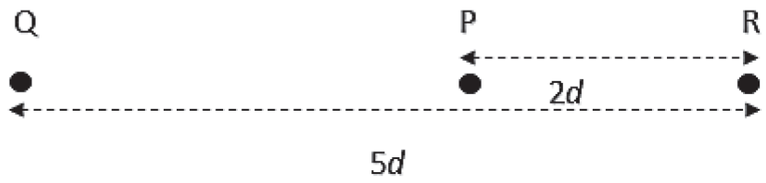
**D** 1 electron (2)

**3.** The centres of two identical metallic spheres, each carrying a charge *Q*, are placed a distance *r* apart. Which ONE of the following pairs of changes (that are made simultaneously) will double the electrostatic force that one charged sphere exerts on the other?

| | | |
|---|---|---|
| **A** | Decrease the distance to $\frac{r}{2}$ | Double the charge on each sphere |
| **B** | Decrease the distance to $\frac{r}{2}$ | Reduce the charge on one sphere to $\frac{Q}{2}$ |
| **C** | Double the distance to $2r$ | Double the charge on each sphere |
| **D** | Decrease the distance to $\frac{r}{2}$ | Reduce the charge on both spheres to $\frac{Q}{2}$ |

(2)

**4.** A negative charge **Q** is placed at a distance 5*d* from another charge **R**. A point **P**, between the charges and a distance of 2*d* from **R** has a zero net electric field.



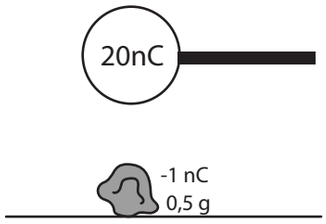

Which of the following combinations concerning the ratio of the charges **Q** to **R**, and the charge on **R** is correct?

| | Ratio of charges Q:R | Charge on R |
|---|---|---|
| **A** | 4:9 | Positive |
| **B** | 3:2 | Negative |
| **C** | 5:2 | Positive |
| **D** | 9:4 | Negative |

(2)

## LONG QUESTIONS

**5.** A small charged sphere on the end of an insulated handle carries a charge of +20 nC. It is brought close to a piece of tissue paper of mass 0,5 g.



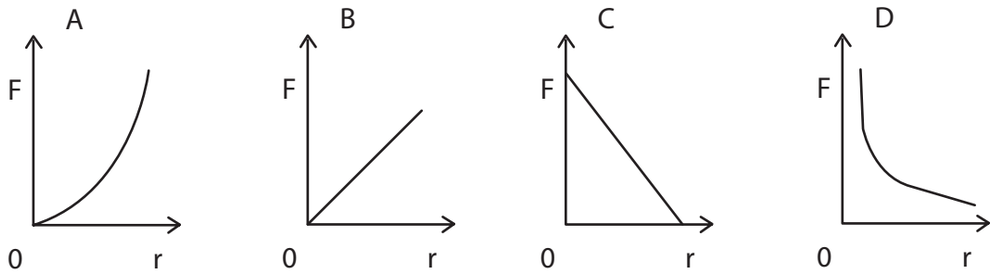

**5.1** If the charge on the piece of tissue paper is –1 nC, what is the maximum distance at which the sphere will be able to pick up the piece of paper? (6)

**5.2** Suppose the mass of the charged sphere and handle is 40 g. Calculate the gravitational force of attraction between the sphere and the tissue paper when they are 1 cm apart. (5)

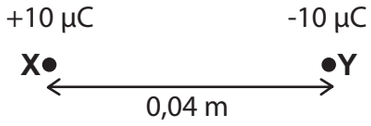
**5.3** State why the force calculated in **5.2** can be ignored in the calculation in **5.1**. (1)

**5.4** Calculate how many electrons are transferred to the sphere when it picks up the piece of paper. (5)

**5.5** Which one of the following graphs is a correct representation of the force between the sphere and the tissue paper as a function of the distance between them? (2)




**6.** Two charged spheres X and Y are placed 0,04 m apart, as shown in the diagram below.




**6.1** Draw the resulting electric field pattern between the charges. (3)

**6.2** Calculate the electrostatic force that **Y** experiences due to charge **X**. (4)

**6.3** Thus state the force that **X** experiences due to **Y**. (1)

**6.4** If **Y** is fixed, but **X** is free to move, will the acceleration experienced by **X** be constant? (1)

**6.5** Explain your answer to **6.4**. (2)

# MARKING GUIDELINES

## MULTIPLE CHOICE

**1.** D ✓✓ $F \propto \frac{1}{d^2}$ If $d$ halves, the force becomes 4 times bigger. (2)

**2.** A ✓✓ The leaves rise more because they are gaining more charge as more electrons are moving onto them; the force with which they repel each other increases. So the object must be negatively charged. (2)

**3.** D ✓✓ $F \propto \frac{1}{d^2}$ If $d$ is reduced to $\frac{1}{3}d$, the force becomes $3^2 = 9$ times bigger. (2)

## LONG QUESTIONS

**4.**

**4.1** $Q_1$ ✓ $Q_2$ ✓ (2)

**4.2** Charge can neither be created nor destroyed,✓ but can be transferred.✓ (2)

**4.3** $Q_{new} = \frac{Q_1 + Q_2}{2} = \frac{-8\checkmark}{2\checkmark} = -4\text{ nC}\checkmark$ (3)

**4.4** $Q_{transferred} = -4 - 4\checkmark = -8\text{ nC}\checkmark$ OR $Q_{transferred} = -12 - (-4) = -8\text{ nC}$ (2)

**4.5** $I = \frac{Q}{t} = \frac{\Delta Q}{\Delta t}\checkmark = \frac{-8 \times 10^{-9}\checkmark}{3 \times 10^{-6}\checkmark} = 2,67 \times 10^{-3}\text{ A}\checkmark$ (4)

**5.** **5.1** **B** experiences a force to the left (an attractive force.) (1)

**5.2.1** Electrons were added to **A**.✓ Electrons flow from negative to positive. ✓ (2)

**5.2.2** $Q_A = Q_B = \frac{-16 + 8}{2} = -4\,\mu\text{C}\checkmark$

$F = \frac{kQ_AQ_B}{r^2}$

$1,6 = \frac{9 \times 10^9 \times 4 \times 10^{-6} \times 4 \times 10^{-6}\checkmark}{d^2}$

$d^2 = \frac{9 \times 10^9 \times 4 \times 10^{-6} \times 4 \times 10^{-6}\checkmark}{1,6}$

$d^2 = 0,09$

$d = 0,3\text{ m}\checkmark$ (3)

**6.** **6.1** $E_8 = \dfrac{kQ}{r^2}$ $\qquad$ $E_6 = \dfrac{kQ}{r^2}$

$E_8 = \dfrac{9\times10^9\times(8\times10^{-6})}{(0,2+0,1)^2}$ ✓ $\qquad$ $E_6 = \dfrac{9\times10^9\times(6\times10^{-6})}{(0,1)^2}$ ✓

$E_8 = 8,00\times10^5\ \text{N·C}^{-1}$ right ✓ $\qquad$ $E_6 = 5,40\times10^6\ \text{N·C}^{-1}$ left ✓ (5)

$E_{net} = 4,60\times10^6\ \text{N·C}^{-1}$ left ✓

**6.2** $E = \dfrac{F}{q}$

$q = \dfrac{F}{E} = \dfrac{7,36\times10^{-13}}{4,6\times10^6}$ ✓ $= 1,6\times10^{-19}$ C ✓ (2)

## CONSOLIDATION EXERCISE

**[38 MARKS]**

## MULTIPLE CHOICE

**1.** A ✓✓ The new charges are +2Q and –Q, therefore they attract each other.
The new distance is $2d$, therefore the force $(2)^2 = 4$ times smaller. (2)

**2.** B ✓✓ Combined charge = $-3{,}2 \times 10^{-19}$ C.
Charge is shared equally by both spheres.
Therefore each has a charge of $-1{,}6 \times 10^{-19}$ C.
Change in charge on X= $-1{,}6 \times 10^{-19} - (3{,}2 \times 10^{-19})$
$= -4{,}8 \times 10^{-19}$ C
i.e. 3 electrons are transferred to X. (2)

**3.** B ✓✓ Halving the distance makes the force 4 times larger, and halving the charge on one of the charges reduces the force to half as much. The combined effect of these changes doubles the force. (2)

**4.** D ✓✓ **Q** ⟵ 3d ⟶ **P** ⟵ 2d ⟶ **R**
**Q** & **R** must both be negative, in a ratio of $3^2$ to $2^2$. (2)

## LONG QUESTIONS

**5.** **5.1** $F_{attraction} = F_g$(paper) ✓ $= 0{,}5 \times 10^{-3}$✓$\times 9{,}8 = 0{,}0049$ N✓

$F = \frac{kQ_1Q_2}{r^2}$ (no c.o.e. to answer)

$0{,}0049 = (9 \times 10^9 \times 1 \times 10^{-9}$ ✓$\times 20 \times 10^{-9}) / r^2$

$r = 0{,}0061$ m or 6,1 mm ✓✓ (6)

**5.2** $F = \frac{GM_1M_2}{r^2}$ ✓✓

$= (6{,}7 \times 10^{-11} \times 0{,}5 \times 10^{-3}$✓$\times 40 \times 10^{-3}$✓$) / (1 \times 10^{-2}$✓$)^2$

$= 1{,}34 \times 10^{-11}$ N ✓ (5)

**5.3** It is negligibly small ✓ in comparison to the electrostatic force. (1)

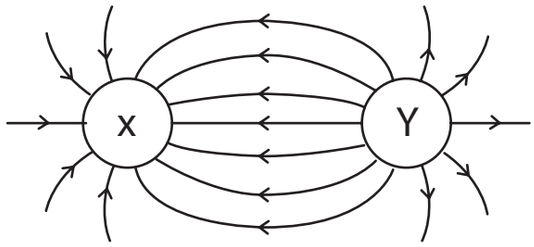
**5.4** New charge on each = (20 – 1) / 2 = 9,5 nC✓

$\Delta Q = 20 - 9{,}5 = 10{,}5$ nC✓

$ne^- = 10{,}5 \times 10^{-9}$✓$/ 1{,}6 \times 10^{-19}$✓$= 6{,}56 \times 10^{10}$ electrons✓ (5)

**5.5** D ✓✓ (2)

**6.**




**6.1** Correct electric field pattern ✓ arrows ✓ symmetry ✓ (3)

**6.2** $F = \frac{kQ_1Q_2}{r^2} = \frac{9 \times 10^9 \times (10 \times 10^{-6})^2 \checkmark}{(0,04)^2 \checkmark}$ = 562,5 N ✓left✓ (attraction) (4)

**6.3** $5{,}63 \times 10^2$ N right ✓ (1)

**6.4** No ✓ (1)

**6.5** As **X** gets closer to **Y**, *r* decreases✓, thus the *F* increases✓ and *a* increases. (2)

# Topic 10: Electromagnetism

## WORKSHEET QUESTIONS

### MULTIPLE CHOICE

**1.** Which of the following will give the most effective (strongest) electromagnet?

**A** A single wire with a high current flowing through it.

**B** A single wire with a low current flowing through it.

**C** Many turns of wire in a coil, with a low current flowing through the coil.

**D** Many turns of wire in a coil, with a high current flowing through the coil. (2)

**2.** A learner pulls a magnet away from a coil (or solenoid) as shown.

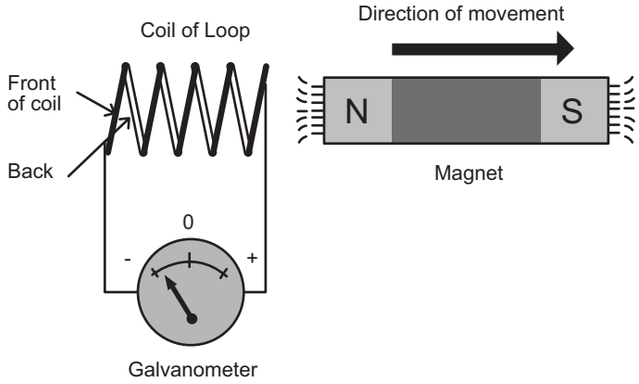



Image source: http://www.electronics-tutorials.ws/electromagnetism/electromagnetic-induction.html

In order to increase the induced current, the learner should:

**A** move the magnet slowly in the opposite direction.

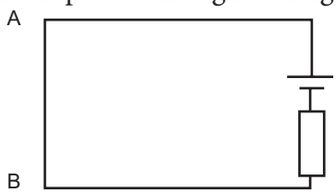
**B** hold the magnet still for a long period of time.

**C** move the magnet as quickly as possible into the centre of the solenoid, then keep it stationary there.

**D** move the magnet through the coil continuously as quickly as possible. (2)

## LONG QUESTIONS

**3.** A current passes through a straight conductor **AB** as shown in the diagram below.

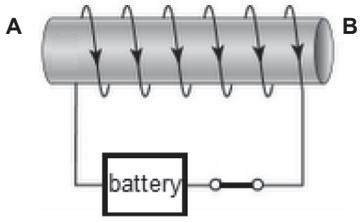



**3.1** Does the current pass from **A** to **B** or from **B** to **A**? (1)

**3.2** Draw a diagram of the magnetic field that forms around the wire **AB**. (3)

**3.3** What would the effect of reversing the cell be on the magnetic field? (2)

**4.** A solenoid is shown in the diagram below.




The current passes into the solenoid at **A** and out of the solenoid at **B**.

**4.1** Describe the shape the magnetic field around the solenoid. (2)

**4.2** What type of magnet has a similar magnetic field to that of a solenoid? (1)

**4.3** Which end (**A** or **B**) is the north pole of the solenoid? (1)

**4.4** What rule did you use to determine this? Describe the rule. (2)

**5.** A magnet is brought near a solenoid or coil as shown in the diagram below.

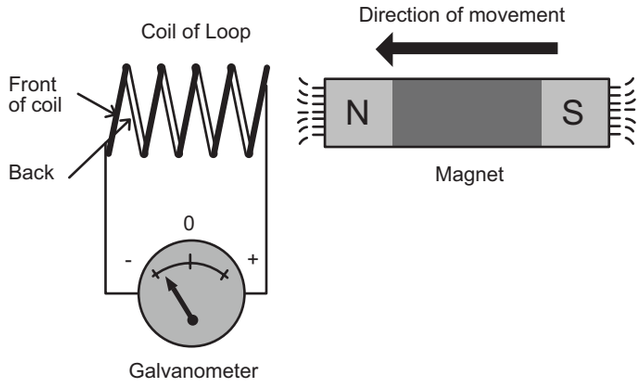



Image source: http://www.electronics-tutorials.ws/electromagnetism/electromagnetic-induction.html

**5.1** Why does the galvanometer deflect as the magnet is brought near to the coil? (1)

**5.2** What rule can be used to predict the direction of the induced current? (1)

**5.3** Which way will the current pass through the coil? (Up the back or up the front.) (1)

**5.4** Give three ways in which the strength of the induced current can be increased. (3)

**6.** **6.1** State Faraday's law of electromagnetic induction. (2)

**6.2** Give the equation that describes this law and give the meaning of each of the symbols. (4)

**6.3** A magnet is pushed towards a solenoid as shown in the diagram below.

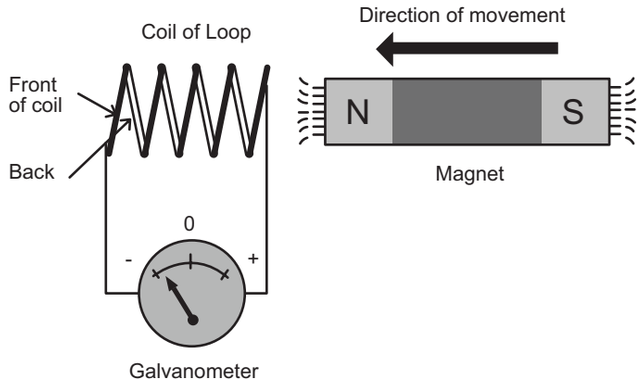



Image source: http://www.electronics-tutorials.ws/electromagnetism/electromagnetic-induction.html

Is the magnetic flux linkage increasing, staying the same or decreasing? Explain your answer. (2)

**7.** A coil with 200 windings (turns) is rotated so that the magnetic flux linkage with each winding changes from $1 \times 10^{-4}$ Wb to $5 \times 10^{-4}$ Wb in 0,2 s.

**7.1** Calculate the induced emf in the coil. (3)

**7.2** Was the coil rotated so that the angle between the normal to the plane of the coil and the magnetic field became closer to 90° or closer to 0°? Explain your answer. (2)

**7.3** The circuit connected to the coil has a resistance of 4 Ω. Calculate the induced current. (2)

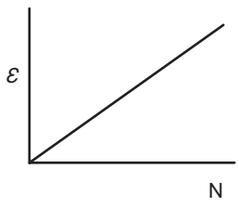
## CONSOLIDATION EXERCISE

**[40 MARKS]**

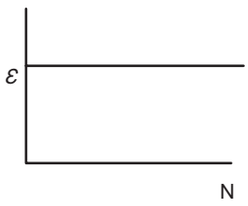
## MULTIPLE CHOICE

**1.** Consider the emf induced in a coil. Which of the following graphs correctly describes the relationship between the induced emf and the number of turns in the coil?

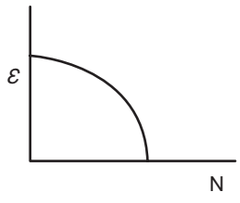
**A**



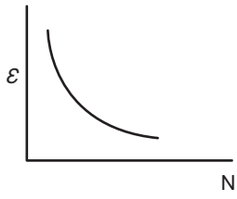

**B**




**C**




**D**




(2)

**2.** A coil of $N$ turns has a surface area of $A$ in a magnetic field $B$. A second coil of $2N$ turns has a surface area of $3A$ and is in a magnetic field of $\frac{1}{2}B$. The two coils rotate at the same speed.

The first coil has an average induced emf of V. What will be the average induced emf of the second coil?

**A** V

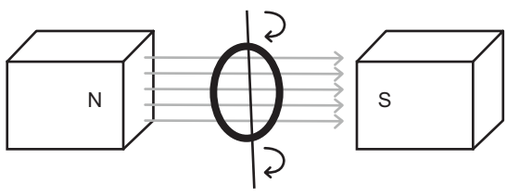
**B** 2V

**C** 3V

**D** 6V (2)

## LONG QUESTIONS

**3.** A learner does an experiment to see how the number of windings in a coil affects the induced emf. She puts a coil inside a uniform magnetic field, rotates the coil through a fixed angle and measures the induced emf across the coil. She then changes the number of turns in the coil and repeats the measurements.




**3.1** What is the independent variable of this experiment? (1)

**3.2** What is the dependent variable? (1)

**3.3** Give 3 variables that must be kept constant. (3)

**3.4** She obtains the following results:

| Number of windings | Induced emf (mV) |
|---|---|
| 1 | 0,25 |
| 10 | 2,4 |
| 20 | 4,9 |
| 40 | 9,9 |

**3.4.1** On graph paper, draw a graph of the results of this experiment. (6)

**3.4.2** State the conclusion for this experiment. (2)

**4.** A coil of wire, with a single loop or winding, is placed in a uniform magnetic field so that the normal to the plane of the coil is at an angle of 30° to the magnetic field which is 0,16 T.

**4.1** The area of the coil is 30 $cm^2$. Calculate the magnetic flux linkage through the coil. (3)

**4.2** The coil is rotated in 0,2 s so that the magnetic flux linkage halves.

**4.2.1** What is the new magnetic flux linkage? (1)

**4.2.2** Calculate the induced emf in the coil. (3)

**5.** A coil of wire with 100 turns is placed in a uniform magnetic field so that the plane of coil is at 90° to the magnetic field. The coil is then rotated in 0,1 s so that the plane of the coil is parallel to the coil.

**5.1** In which position will the magnetic flux linked to the coil be zero? (1)

**5.2** If the average emf induced in the coil is 0,5 V, what is the maximum magnetic flux linked to the coil? (4)

**5.3** The area of the coil is 0,04 $m^2$. What is the magnetic flux density (strength of the magnetic field)? (3)

**6.** A coil of wire turns in a uniform magnetic field of 0,5 T. The coil has 10 turns of wire in it and an area of 0,025 $m^2$. The average induced emf as the coil turns from its plane being parallel to the magnetic field to being at 90° to the magnetic field is 0,4 V.

**6.1** At which position (coil parallel to or at 90° to the magnetic field) is the magnetic flux linkage the greatest? (1)

**6.2** How long does the coil take to rotate 90°? (4)

**6.3** What law did you use in finding your answer to **6.2**? (1)

**6.4** State that law in words. (2)

# MARKING GUIDELINES

## MULTIPLE CHOICE

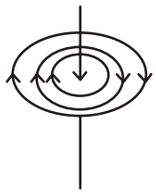
**1.** D ✓✓ A higher current and more turns will give a greater electromagnetic effect. (2)

**2.** D ✓✓ A faster moving magnet provided a greater rate of change of magnetic flux linkage. (2)

## LONG QUESTIONS

**3.** **3.1** A to B ✓ (1)

**3.2** ✓circular field ✓arrows correct✓more than 2 field lines shown. (3)



**3.3** The field would have the same shape✓ but be in the opposite direction.✓ (3)

**4.** **4.1** The magnetic field goes through the centre of the solenoid✓, then in an oval ✓shape; it goes back outside the solenoid to the start. (2)

**4.2** A bar magnet. ✓ (1)

**4.3** **B**✓ (1)

**4.4** The 'right hand solenoid rule' ✓(any equivalent description.) The fingers of the right hand curl in the direction of the current and the thumb points to the north pole of the magnet. (2)

**5.** **5.1** Because a current✓ is induced in the coil. (1)

**5.2** The right hand solenoid rule.✓ (1)

**5.3** Up the back.✓ (1)

**5.4** Increase the speed of the magnet's movement✓; increase the strength of the magnet✓; increase the number of the turns✓; increase the area of the turns.✓ (Any 3 of these) (3)

**6.** **6.1** The induced emf✓ in a coil is equal to the rate of change of the magnetic flux.✓ (2)

**6.2** $\varepsilon = -N\frac{\Delta\Phi}{\Delta t}$

ε = induced emf; $N$ = number of turns (windings) in the coil; ΔΦ = change in magnetic flux linkage, and $\Delta t$ = time. The negative sign shows that the induced emf opposes the change in magnetic flux. (4)

**6.3** It is increasing✓, as the magnet gets closer to the solenoid magnetic flux linkage between the magnet and the coil increases.✓ (2)

**7.** **7.1** $\varepsilon = -N\frac{\Delta\Phi}{\Delta t} = -200\frac{(5\times10^{-4}-1\times10^{-4})}{0,2} = -0,4\text{ V}$ ✓ (3)

**7.2** The angle between the normal to the plane and the magnetic field became closer to 0° ✓(i.e. the plane of the coil and the magnetic field were closer to 90°) because the magnetic flux linkage increased. ✓ (2)

**7.3** $I = \frac{V}{R} = \frac{0,4}{4}$ ✓$= 0,1\text{ A}$ ✓ (2)

## CONSOLIDATION EXERCISE

**[40 MARKS]**

### MULTIPLE CHOICE

**1.** A ✓✓ $\varepsilon = -N\frac{\Delta\Phi}{\Delta t}$ (2)

**2.** C ✓✓ $\varepsilon = -N\frac{\Delta AB\cos\theta}{\Delta t}$ (2)

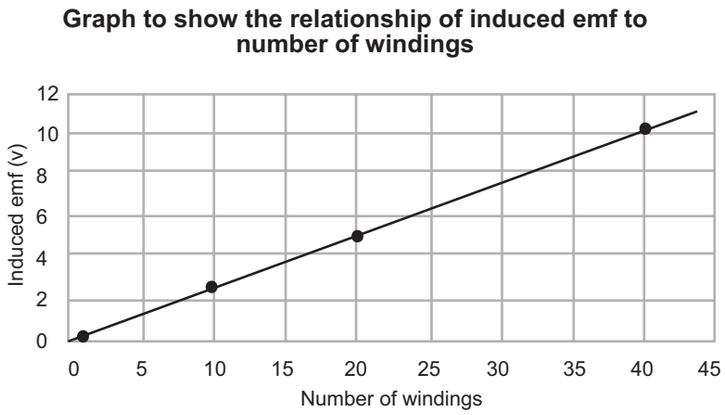
### LONG QUESTIONS

**3.** **3.1** Number of windings ✓ (1)

**3.2** Induced emf ✓ (1)

**3.3** Area of coil, ✓ B ✓(magnetic field), final and initial angles, ✓ time for rotation. (Any three of the above) (3)

**3.4.1**




Heading ✓; axes with labels✓; plotted points ✓✓; line of best fit ✓✓ (2)

**3.4.2** The induced emf is directly proportional ✓ to the number of windings.✓ (2)

**4.** **4.1** $\Phi = BA\cos\theta = 0,16\checkmark(0,003)\cos 30°\checkmark = 0,000\ 416\ \text{Wb}\checkmark$ (3)

**4.2.1** 0,000 208 Wb ✓(c.o.e.) (1)

**4.2.2** $\Phi = -n\frac{\Delta\Phi}{\Delta t} = \frac{-1(0,000\ 208 - 0,000\ 416)}{0,2} = 0,001\ 04\ \text{V}\checkmark$ (3)

**5.** **5.1** When the plane of the coil is at 90°✓ (1)

**5.2** $\varepsilon = -n\frac{\Delta\Phi}{\Delta t}$

$0,5\checkmark = -(100)\frac{\Delta\Phi}{0,1}\checkmark$

$\Delta\Phi = -0,005\checkmark$

$\Phi_{max} = 0,0005\ \text{Wb}\checkmark$ (4)

$$\Phi_{max} = BA\cos\theta$$

**5.3** $0,0005 \checkmark = B(0,04)(1) \checkmark$ (3)

$$B = 0,0125 \text{ T} \checkmark$$

**6.** **6.1** When the plane of the coil is at 90°✓ (1)

**6.2** $$\varepsilon = -n\frac{\Delta\Phi}{\Delta t}$$

$$0,4 \checkmark = -(10)\frac{(0-0,5)\checkmark(0,025)}{\Delta \text{t}} \checkmark$$ (4)

$$\Delta t = 0,125 \text{ s} \checkmark$$

**6.3** Faraday's law (1)

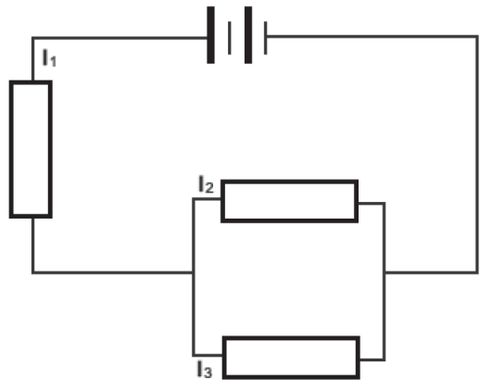
**6.4** The induced emf✓ in a coil is equal to the rate of change of the magnetic flux.✓ (2)

# Topic 11: Electric Circuits

## WORKSHEET QUESTIONS

### MULTIPLE CHOICE

**1.** Consider the circuit diagram shown below. The ammeters read currents of $I_1$, $I_2$ and $I_3$ respectively.




Which of the equations for the current in the above circuit is correct?

**A** $I_1 = I_2 + I_3$

**B** $I_2 = I_1 + I_3$

**C** $I_3 = I_1 + I_2$

**D** $I_1 = I_3$ (2)

**2.** An ammeter is connected in series with a resistor in an electric circuit because it has

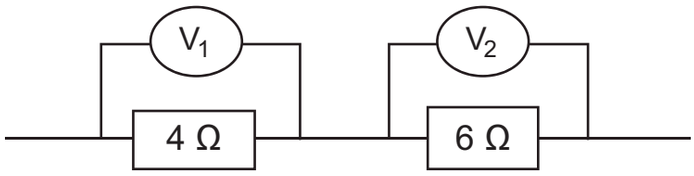
**A** a low resistance and measures potential difference.

**B** a high resistance and measures current strength.

**C** a low resistance and measures the rate of flow of charge.

**D** a high resistance and measures the number of charges flowing through it each second. (2)

**3.** Consider the circuit diagram shown below:




When current passes through both resistors...

**A** $V_1$ has a higher reading than $V_2$.

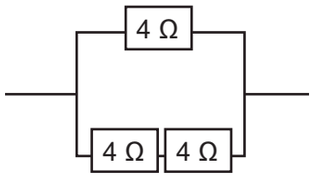
**B** $V_2$ has a higher reading than $V_1$.

**C** the reading on $V_1$ and $V_2$ is the same.

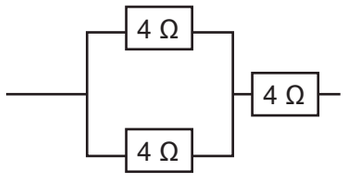
**D** the potential difference is inversely proportional to resistance. (2)

**4.** Three identical resistors of 4 Ω are connected to give a combined resistance of 6 Ω. Which of the following circuit diagrams correctly shows how this can be done?

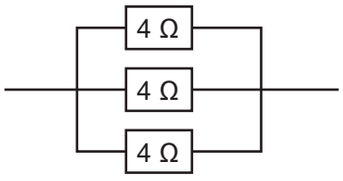
A



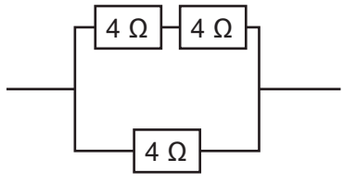

B




C



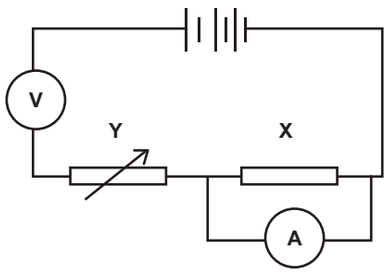

D




(2)

## LONG QUESTIONS

**5.** Tshepo and Mo are given a conductor X and requested to carry out an investigation to determine whether or not conductor X is ohmic. They set up a circuit as shown in the circuit diagram below. Ignore the internal resistance of the battery.




**5.1** State Ohm's law. (2)

**5.2** Identify two errors made by Tshepo and Mo when connecting the circuit shown above. (2)

**5.3** What is the function of component Y is this investigation? (2)

Tshepo and Mo collect the following ammeter and voltmeter readings during their investigation.

| I (A) | V (V) |
|---|---|
| 0,2 | 0,55 |
| 0,4 | 1,10 |
| 0,6 | 1,65 |
| 0,8 | 2,20 |
| 1,0 | 3,30 |
| 1,2 | 5,00 |

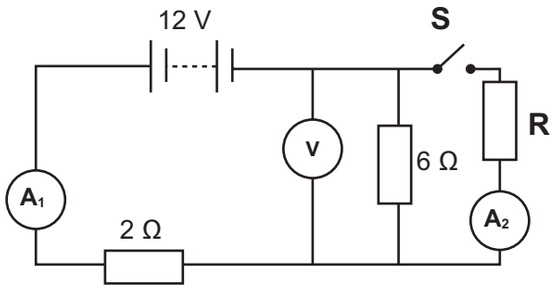
**5.4** Plot a graph of potential difference (y-axis) versus current (x-axis) on graph paper. Draw a line which best fits **all** the plotted points. (6)

**5.5** Calculate the gradient of the graph when the current in conductor X is less than 0,5 A. Provide an appropriate unit for your answer. (3)

**5.6** Is conductor X an ohmic conductor (for all currents) in this investigation? Justify your answer. (2)

**5.7** Explain the trend in your graph when the current in conductor X is greater than 0,8 A. (2)

**6.** In the circuit diagram below the battery has negligible internal resistance.




With the switch, S OPEN, determine the reading on

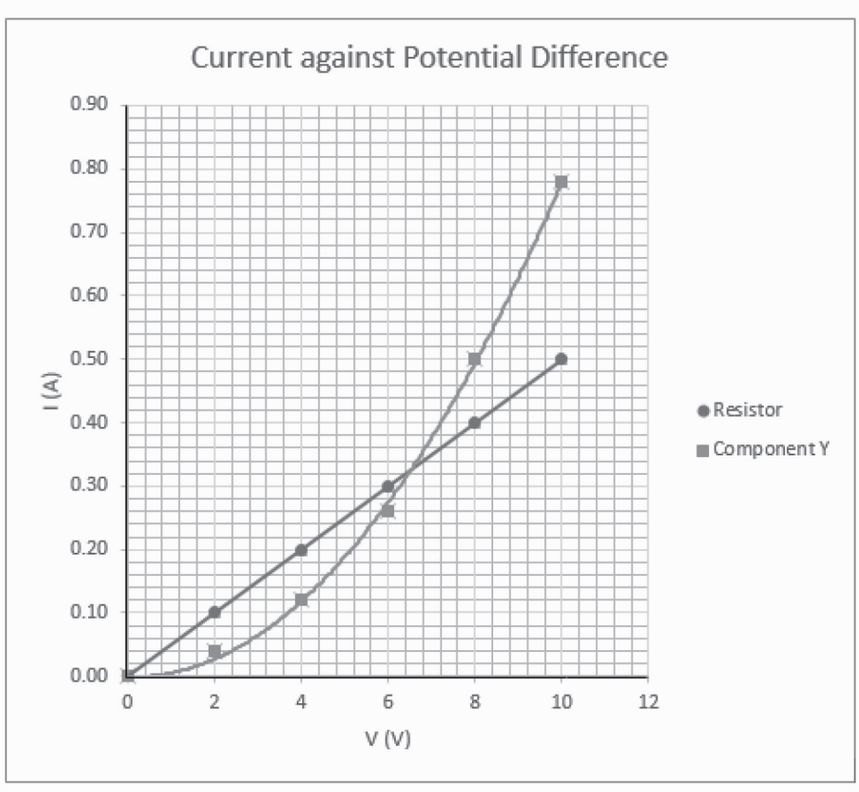
**6.1** ammeter $A_1$. (3)

**6.2** voltmeter V. (2)

The switch S is now CLOSED, and the reading on voltmeter V decreases.

**6.3** If the reading on $A_1$ is three times that of $A_2$, what is the resistance of resistor R? (4)

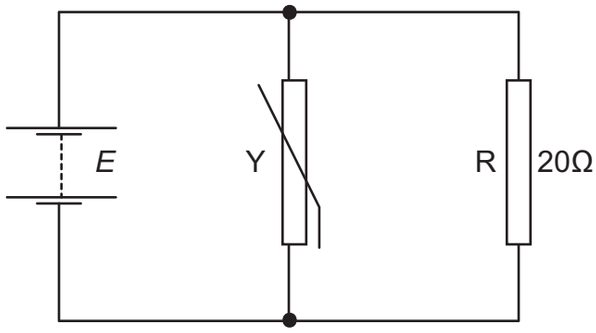
**7.** The variation with potential difference V of the current I in a component Y and in a resistor R are shown in the graph. **The current is plotted on the y axis and the potential difference is plotted on the x axis.**



**7.1** **7.1.1** Use the graph to explain how it can be deduced that resistor R has a constant resistance of 20 Ω. (3)

**7.1.2** Is component Y an ohmic conductor? Give a reason for your answer. (2)

**7.2** The component Y and the resistor R are connected in parallel.




A power pack (or a battery with a variable voltage ***E***) with negligible internal resistance is connected across the parallel combination.

Use data from the graph to determine:

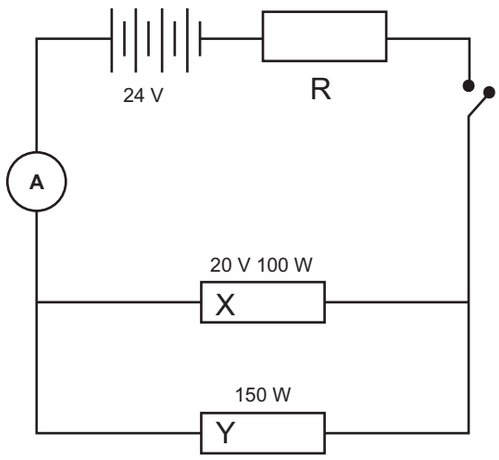
**7.2.1** The current in the battery for an voltage of 4,0 V. (3)

**7.2.2** The total resistance of the circuit for a voltage of 8,0 V. (3)

**7.2.3** The electrical energy used in R with a voltage of 8,0 V for 20 s. (3)



**8.** Three electrical devices, X, Y and R, are connected to a 24 V battery as shown in the circuit diagram below. The power rating of each of the devices X and Y are indicated in the diagram. With switch $S_1$ closed, the devices function as rated.




If the power rating of resistor X is 100 W and the potential difference across resistor X is 20 V then calculate the ...

**8.1.** current passing through resistor X. (3)

**8.2** current flowing through resistor Y. (3)

**8.3.** total resistance of the parallel circuit. (3)

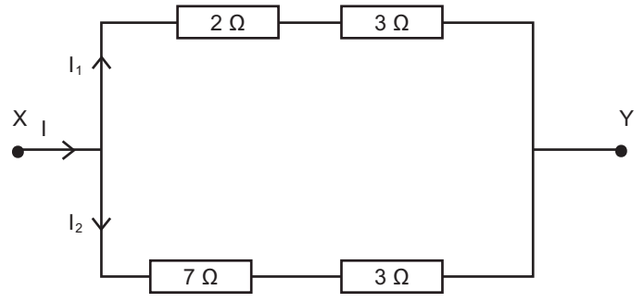
**8.4.** resistance of resistor R. (3)

## CONSOLIDATION EXERCISE

**[45 MARKS]**

## MULTIPLE CHOICE

**1.** In the section of a circuit represented below, a potential difference is applied across XY. The current I, at X divides into $I_1$ and $I_2$.




Which one of the following is true of current $I_2$?

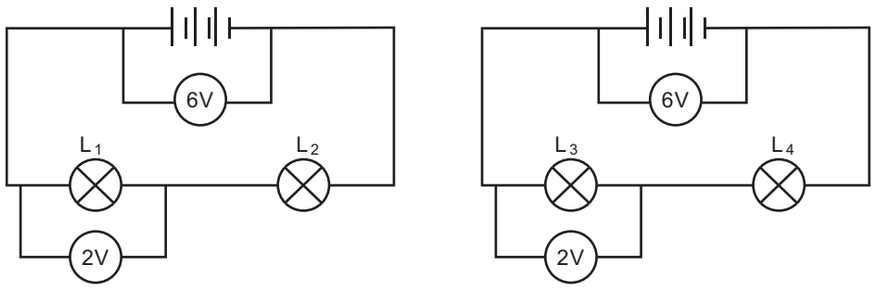
**A** $I_2 = I_1 \times \frac{15}{50}$

**B** $I_2 = I_1 \times \frac{10}{15}$

**C** $I_2 = I_1 \times \frac{5}{10}$

**D** $I_2 = I_1 \times \frac{10}{5}$ (2)

**2.** Two identical 6 V batteries are connected in series with different bulbs $L_1$, $L_2$, $L_3$ and $L_4$ as shown below. The potential difference measured across $L_1$ and $L_3$ is 2 V as shown in both circuits.

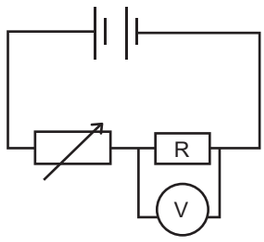



Possible resistance values for the bulbs are:

| | $L_1$ | $L_2$ | $L_3$ | $L_4$ |
|---|---|---|---|---|
| A | 2 Ω | 6 Ω | 6 Ω | 3 Ω |
| B | 1 Ω | 2 Ω | 3 Ω | 5 Ω |
| C | 3 Ω | 6 Ω | 2 Ω | 4 Ω |
| D | 2 Ω | 4 Ω | 6 Ω | 10 Ω |

(2)

**3.** In the circuit represented by the diagram below, the resistance of resistor R is independent of temperature and the battery has negligible internal resistance.




When the voltmeter reading is V, the power dissipated in resistor R is P. The rheostat is adjusted until the reading on the voltmeter is 2 V. The power dissipated in resistor R is now equal to:

**A** $\frac{1}{4}$P

**B** P

**C** 2P

**D** 4P (2)

**4.** When a lamp is connected to a 80 V source, the power dissipated is P. The same lamp is now connected to an 80 V source. Assume that the resistance of the lamp remains constant. The power dissipation will now be equal to:

**A** 240 V

**B** 480 V

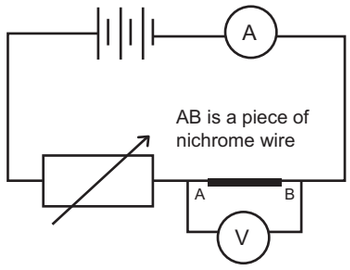
**C** 640 V

**D** 720 V (2)



## LONG QUESTIONS

**5.** Reabetswe assembled the following circuit to determine whether a nichrome wire of 500 mm, with a diameter of 0,1 mm, obeys Ohm's Law.




**5.1** What could be a possible hypothesis for this experiment? (2)

**5.2** Name each of the following in Reabetswe's experiment:

**5.2.1** The dependent variable

**5.2.2** The independent variable.

**5.2.3** A controlled variable. (3)

**5.3** Reabetswe adjusts the variable resistor and measures the potential difference across **AB** for every current reading (the ammeter reading).

Explain which variable Reabetswe should place on the vertical axis of the graph. (2)

Reabetswe records the following readings:

| AMMETER READING (A) | VOLTMETER READING (V) |
|---|---|
| 0,8 | 0,5 |
| 1,8 | 1,1 |
| 2,2 | 1,4 |
| 2,8 | 1,7 |

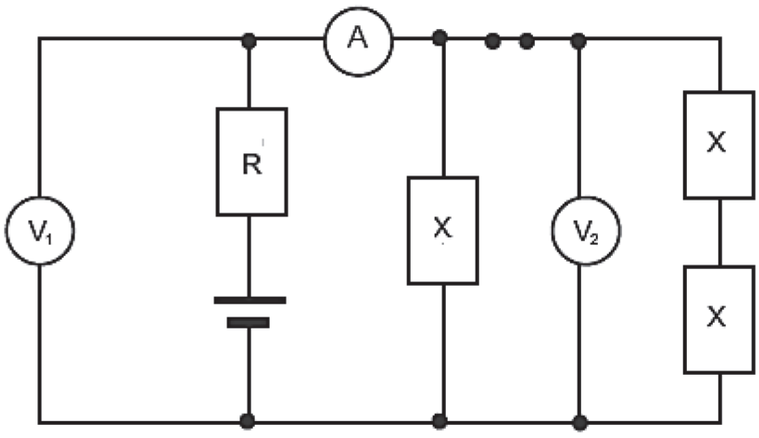
**5.4** Use the data in the table and using graph paper, draw a graph showing the relationship between the data. Extrapolate (lengthen) your graph so that it passes through the origin.. (6)

**5.5** Describe the relationship between between the ammeter reading and the voltmeter reading that is shown on the graph. Give a reason for your answer. (3)

**6.** The circuit diagram below shows a battery with an emf of 6,0 V connected to four resistors, an ammeter and two voltmeters.

The battery has no internal resistance. The resistances of all the meters $\mathbf{V_1}$, $\mathbf{V_2}$ and **A** are such that they do not influence the currents and potential differences in the circuit.

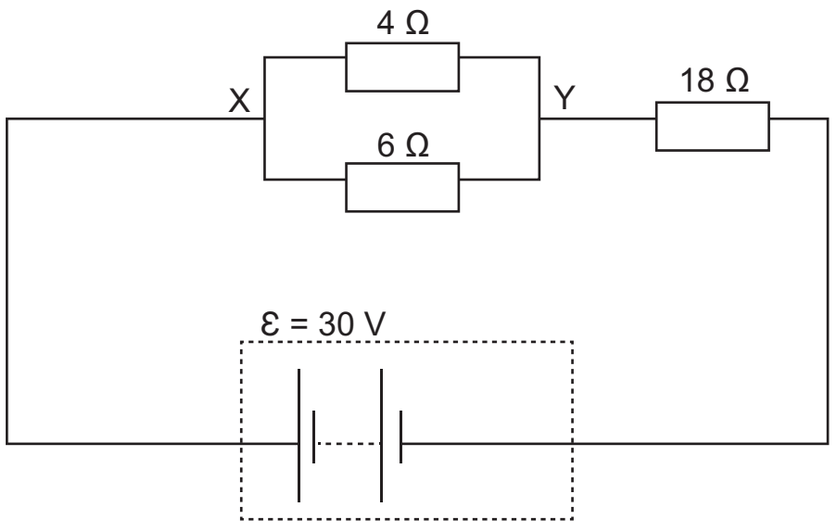
Three of the resistors have identical resistances (**X** Ω) and the fourth has a resistance of **R** Ω. The readings on voltmeter $\mathbf{V_1}$ and the ammeter are 4,8 V and 0,10 A respectively.




**6.1** Calculate the equivalent resistance of the three **X** Ω resistors. (2)

**6.2** Calculate the value of **X**. (4)

**7.** Three different resistors are connected in a circuit as shown below. The battery has an emf of 30 V. The resistance of the connecting wires and the battery is negligible.




**7.1** What is the total resistance of the circuit? (4)

**7.2** Calculate the current passing through the battery. (3)

**7.3** What is the current in the 4 Ω resistor? (3)

**7.4** What is the power dissipated in the 4 Ω resistor? (3)

**7.5** What would the effect be on the main current in each of the following situations when each change is made individually? Only use the words INCREASES, DECREASES or STAYS THE SAME in your answer.

**a)** An additional 10 Ω resistor is added as another parallel branch to the parallel connection.

**b)** An additional 30 V battery is added in parallel. (2)

# MARKING GUIDELINES

## MULTIPLE CHOICE

**1.** A ✓✓ Current divides in parallel. (2)

**2.** C ✓✓ (2)

**3.** B ✓✓ $V = RI$ (2)

**4.** B ✓✓ $R_{total} = R_{parallel} + 4 = 2 + 4 = 6\ \Omega$ (2)

## LONG QUESTIONS

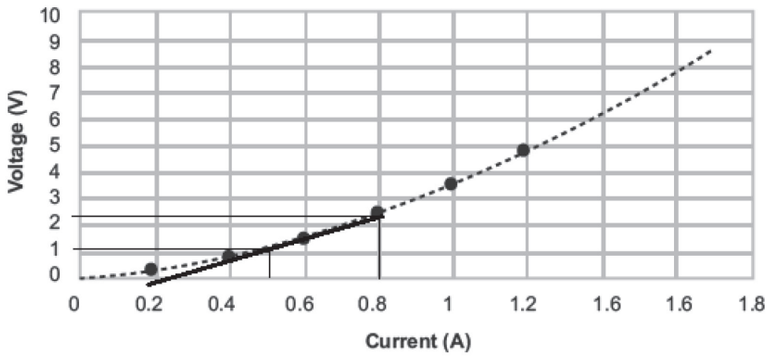
**5.** **5.1** The voltage across a conductor ✓is directly proportional to the current through it✓ provided that the physical conditions such as temperature remain constant.✓ (3)

**5.2** They connected the voltmeter in series, not in parallel. ✓
They connected the ammeter in parallel, not series. ✓ (2)

**5.3** To vary the resistance✓✓ (and therefore current.) (2)

**5.4** Heading✓; axes with labels and units✓; points plotted ✓✓; line of best fit✓✓ (6)

Graph to show the relationship of voltage to current




**5.5** Draw the tangent to the curve at 0,5 A.
Gradient $= \frac{\Delta y}{\Delta x} = \frac{2,3 - 1.1}{0,8 - 0,5}$✓$= 4,00\ \Omega$✓ (3)

**5.6** Non-ohmic✓ as it is not a straight line the whole way.✓ (2)

**5.7** As the current increases, the resistor gets hotter✓ and its resistance increases.✓ (2)

**6.** **6.1** $I = \frac{V}{R}$✓$= \frac{12}{8}$✓
$= 1,5$ A✓ (3)

**6.2** $V = IR = 1,5 \times 6$✓
$= 9$ V✓ (2)

**6.3** Let $A_2(I_2)$ be **x** $\therefore A_1(I_1) = \mathbf{3x}$

$V_{6\Omega} = 6(3x - x) = 12x$ ✓

$V_{6\Omega} = V_{Rparallel} = 12x$

$\therefore R_R = \frac{V_R}{I_2} = \frac{12x}{x}$ ✓$= 12\ \Omega$ ✓

$OR\ \ A_1 = 3A_2\ \ so\ \ I_{6\Omega} = 2I_R\ \ so\ \ R_R = 2R_{6\Omega};\ \ R_R = 12\ \Omega$ (4)

**7. 7.1 7.1.1** The slope is constant therefore the resistance is constant. Slope = 1/R✓

$R$ = 8✓/0,4 ✓= 20 Ω (3)

**7.1.2** Not ohmic as the slope is not constant. (2)

**7.2 7.2.1** $I_T = I_Y + I_R$

= 0,1✓ + 0,2 ✓= 0,3 A✓ (3)

**7.2.2** For 8 V the total current of both resistors is 0,5 + 0,4 = 0,9 A ✓

$V$ = 8 V

$R = V/I$ = 8✓/0,9 = 8,9 Ω✓ (3)

**7.2.3** $E = VIt = 8 \times 0,4$ ✓$\times 20$ ✓$= 64$ J ✓ (3)



**8. 8.1** $P = VI$

$100$ ✓ $= 20$ ✓$I$

$I = 5$ A ✓ (3)

**8.2** $P = VI$

$150$ ✓ $= 20$ ✓$I$

$I = 7,5$ A ✓ (3)

**8.3** $R = \frac{V}{I} = \frac{20\ ✓}{(5 + 7,5)\ ✓} = 1,6\ \Omega$ ✓ (3)

**8.4** $R = \frac{V}{I} = \frac{24 - 20\ ✓}{(5 + 7,5)\ ✓} = 0,32\ \Omega$ ✓ (3)

## CONSOLIDATION EXERRCISE

**[45 MARKS]**

## MULTIPLE CHOICE

**1.** C ✓✓ $I_2 = \frac{1}{2} I_1$ because the lower branch has twice the resistance of the top branch. (2)

**2.** C ✓✓ $V = RI$ (2)

**3.** D ✓✓ $P = \frac{V^2}{R}$ (2)

**4.** A ✓✓ $P = \frac{V^2}{R}$ (2)

## LONG QUESTIONS

**5.** **5.1** The voltage across the nichrome wire is directly proportional to current (variables ✓; relationship ✓) (2)

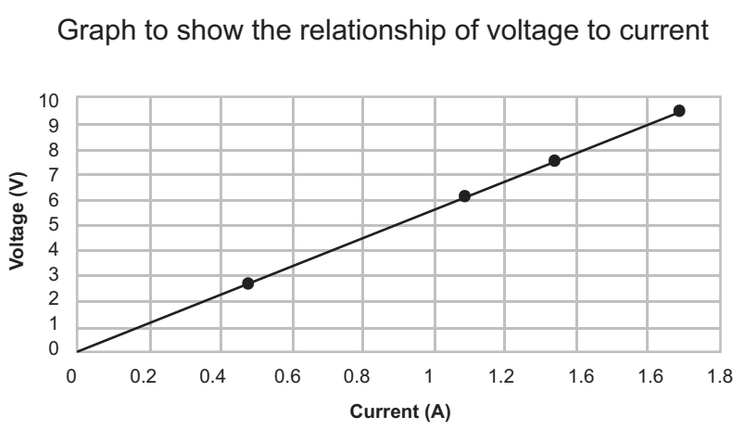
**5.2** **5.2.1** Voltage ✓

**5.2.2** Current ✓

**5.2.3** Temperature (or thickness etc.) ✓ (3)

**5.3** Voltage✓ as it is the dependent variable. ✓ (2)

**5.4** Heading ✓; axes ✓; plotting points ✓✓; line of best fit ✓✓ (3)




**5.5** $V \propto I$ ✓. Straight line ✓ through origin ✓ (3)

**6.** **6.1** $X_{Equivalent} = V/I$

$V$ across the three resistors is 4,8 V

$I_{total}$ through the three resistors is 0,1 A

$X_{Equivalent} = 4{,}8/0{,}1$✓

$X_{Equivalent} = 48\ \Omega$✓ (2)

**6.2** The network consists of two resistors in series (2X) and these are in parallel with another X

$$\frac{1}{R_{Equivalent}} = \frac{1}{2X} + \frac{1}{X} \checkmark$$

$R_{Equivalent} = 2X/3$ ✓

But $R_{Equivalent} = 48$ ✓ $= 2X/3$

$X = 72\ \Omega$ ✓ (4)

**7. 7.1** $\frac{1}{R_{parallel}} = \frac{1}{4} + \frac{1}{6} \checkmark = \frac{5}{12} \checkmark$

$R_{total} = 2,4 + 18 \checkmark = 20,4\ \Omega \checkmark$ (4)

**7.2** $I = \frac{V}{R} = \frac{30 \checkmark}{20.4 \checkmark} = 1,47\ \text{A} \checkmark$ (3)

**7.3** $I_4 = \frac{6}{10} \checkmark \times 1,47 \checkmark\ I_{total} = 0,882\ \text{A} \checkmark$

$OR\ V_{parallel} = I_{parallel} R_{parallel} = 1,47 \times 2.4 = 3,53\ \text{V} \checkmark$

$I_4 = \frac{V}{R} = \frac{3,53}{4} \checkmark = 0{,}882\ \text{A} \checkmark$ (3)

**7.4** $P = VI$ $OR$ $P = I^2R$

$= 3,53 \checkmark \times 0,882 \checkmark$ $OR$ $= (0,882)^2 \checkmark 4 \checkmark$

$= 3,11\ \text{W} \checkmark$ (3)

**7.5** **a)** Increases (total resistance decreases). ✓

**b)** Stays the same (another parallel cell increases cell capacity, but doesn't change V or I). ✓ (2)

# Topic 12: Energy and Chemical Change

## WORKSHEET QUESTIONS

### MULTIPLE CHOICE

**1.** A learner stirs a teaspoon of ammonium nitrate in a beaker of water. The temperature changes from 18 °C to 16 °C. Which statement is true?

**A** The reaction is endothermic because it will not take place if the learner does not supply energy by stirring the water.

**B** The reaction is endothermic because energy was absorbed from the surroundings.

**C** The reaction is exothermic because energy was absorbed from the surroundings.

**D** The reaction is exothermic because energy is released to the surroundings. (2)

**2.** A drop of ether is placed on your hand. Which one of the following is the reason why your hand feels cooler?

**A** Evaporation of the ether is an exothermic process.

**B** Evaporation of ether is an endothermic process.

**C** The ether reacts with moisture from your hand.

**D** The ether was colder than your hand at the start. (2)

**3.** Which statement is true?

**A** Net energy is released in all chemical reactions.

**B** Net energy is absorbed in all chemical reactions.

**C** Energy is given off when bonds are formed.

**D** Energy is absorbed when bonds are formed. (2)

### LONG QUESTIONS

**4.** Define the following terms:

**4.1** Activation energy (2)

**4.2** Bond energy (2)

**4.3** Heat of reaction (2)

**5.** Methane ($CH_4$) burns in oxygen to form carbon dioxide and water. The energy required to break all the bonds in $CH_4$ and $O_2$ is 2 648 kJ.mol$^{-1}$. The energy needed to form all the bonds in $CO_2$ and $H_2O$ is 3 270 kJ·mol$^{-1}$.

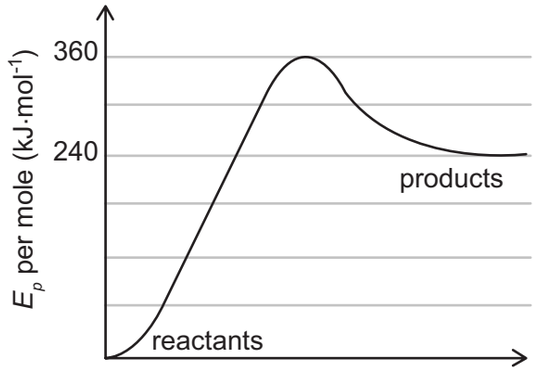
**5.1** Write the balanced reaction equation. (3)

**5.2** Is the reaction is endothermic or exothermic? Justify your answer. (3)

**5.3** Draw a graph of energy per mole against time to show the progress of the reaction. (6)

**5.4** Determine ΔH, the heat of the reaction. (3)

**6.** Consider the graph (shown below) of potential energy per mole for a reaction between gases. Take the potential energy per mole of the reactants as zero.




**6.1** Give the value in kJ·mol$^{-1}$ of the:

**6.1.1** activation energy for the forward reaction. (1)

**6.1.2** activation energy for the reverse reaction. (1)

**6.1.3** energy of the activated complex. (1)

**6.1.4** value of ΔH, the change in enthalpy of the reaction. (1)

**6.2** Does this graph represents an exothermic or an endothermic reaction? Briefly explain your answer. (2)

**7.** Methane reacts with chlorine in the presence of light:

$CH_4 + Cl_2 \rightarrow CH_3Cl + HCI \qquad \Delta H = -99{,}5$ kJ·mol$^{-1}$

Draw an energy diagram for this reaction. Show reactants, products and the heat of reaction. (6)

**8.** The surroundings become warmer when sodium hydroxide (NaOH) pellets dissolve in water, while dissolving ammonium nitrate ($NH_4NO_3$) makes the surroundings colder.

**8.1** Use a table to compare these two reactions in terms of:

**8.1.1** the reaction being endothermic or exothermic.

**8.1.2** energy levels of the reactants and the products.

**8.1.3** the sign of the enthalpy change. (6)

**8.2** Draw a potential energy diagram for each of the reactions. Show the reactants and products and the heat of reaction. (4)

## CONSOLIDATION EXERCISE

**[56 MARKS]**

### MULTIPLE CHOICE

**1.** We know that a reaction is endothermic when the products have ...

**A** higher potential energy than the reactants; ΔH is negative.

**B** higher potential energy than the reactants; ΔH is positive.

**C** lower potential energy than the reactants; ΔH is negative.

**D** lower potential energy than the reactants; ΔH is positive. (2)

**2.** An enthalpy diagram provides information about ...

**A** the oxidation states of the reactants and products.

**B** the average kinetic energy of the reactants and products.

**C** the change in solubility of the reacting substances.

**D** the energy released or absorbed during the reaction. (2)

**3.** Given the balanced equation:

$4\ Fe(s) + 3\ O_2(g) \rightarrow 2\ Fe_2O_3(s) \qquad 1\ 640\ kJ{\cdot}mol^{-1}$

The reaction is ...

**A** endothermic with $\Delta H = +1\ 640\ kJ{\cdot}mol^{-1}$.

**B** endothermic with $\Delta H = -1\ 640\ kJ{\cdot}mol^{-1}$.

**C** exothermic with $\Delta H = +1\ 640\ kJ{\cdot}mol^{-1}$.

**D** exothermic with $\Delta H = -1\ 640\ kJ{\cdot}mol^{-1}$ (2)



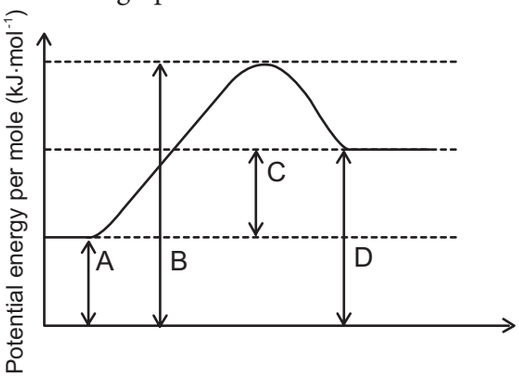
### LONG QUESTIONS

**4.** When solid sodium hydroxide dissolves in water, the temperature of the solution rapidly increases.

**4.1** Compare the total energy of the solid sodium hydroxide (NaOH) with that of the solution and state which is greater. (2)

**4.2** Classify this reaction as endothermic or exothermic. (1)

**5.** Consider the graph below.




**5.1** Select the interval on the diagram that represents the:

**5.1.1** Potential energy of the products (2)

**5.1.2** Heat of reaction (2)

**5.1.3** Activation energy (2)

**5.1.4** Activation energy for the reverse reaction (2)

**5.2** Define the following terms:

**5.2.1** Activation energy (2)

**5.2.2** Activated complex (2)

**6.** Consider the reaction: A + 2B → C. In this reaction, the total energy of the reactants is 80 kJ·mol$^{-1}$, the total energy of the products is 90 kJ·mol$^{-1}$ and the activation energy for the reaction is 120 kJ·mol$^{-1}$.

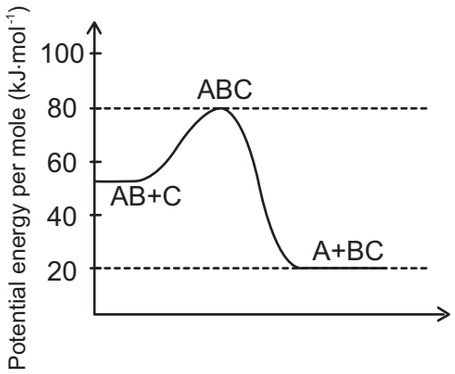
**6.1** Draw a labelled energy diagram for this reaction. (5)

**6.2** State whether the reaction is endothermic or exothermic. Explain briefly. (2)

**6.3** Calculate the heat of reaction for the reaction. (3)

**6.4** Explain the role of the activation energy in the reaction in terms of collision theory. (2)

**7.** Study the energy profile as shown below



**7.1** Determine the activation energy for the reaction. (2)

**7.2** What is the enthalpy change ($\Delta H$) for the reaction? (2)

**7.3** Is the forward reaction endothermic or exothermic? Give a reason for your answer. (2)

**7.4** Which bond is stronger, A—B or B—C? Give a reason for your answer. (3)

**8.** Classify each of the following reactions as either exothermic or endothermic and justify your answer.

**8.1** $2H_2O(\ell) + \text{heat} \rightarrow 2H_2(g) + O_2(g)$ (2)

**8.2** $Mg(s) + C\ell_2(g) \rightarrow MgC\ell_2(s) + \text{heat}$ (2)

**9.** The table shows two different reactions and the temperature change for each reaction.

| Reaction | | Temperature before reaction (°C) | Temperature after reaction (°C) |
|---|---|---|---|
| **A** | Magnesium and hydrochloric acid | 20 | 25 |
| **B** | Citric acid and sodium hydrogen carbonate | 18 | 14 |

**9.1** Describe what you would feel if you held each of the test tubes in your hand. Explain why this happens. (2)

**9.2** Which reaction is endothermic? (1)

**9.3** Explain what it means for a reaction to be endothermic. (2)

# MARKING GUIDELINES

## MULTIPLE CHOICE

**1.** B ✓✓ (2)

**2.** B ✓✓ (2)

**3.** D ✓✓ (2)

## LONG QUESTIONS

**4.** **4.1** This is the minimum energy required to start a chemical reaction. ✓✓ (2)

**4.2** The amount of energy required to break a particular bond in a molecule or the amount of energy released when a new bond is formed. ✓✓ (2)

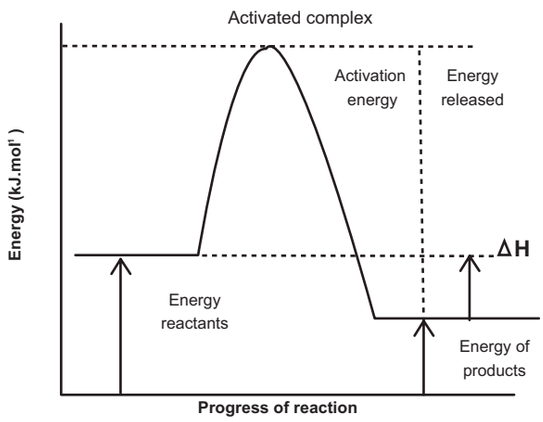
**4.3** The measure of the change in enthalpy/amount of heat energy transferred, during a chemical reaction. ✓✓ (2)

**5.** **5.1** $CH_4 + 2\,O_2 \rightarrow CO_2 + 2\,H_2O$ (3)

✓ ✓ ✓ balancing

**5.2** Exothermic.✓ The amount of energy released on product formation ($3\,270\ kJ{\cdot}mol^{-1}$) is greater ✓ than the amount of energy required to break the bonds of the reactants ($2\,648\ kJ{\cdot}mol^{-1}$).✓ (3)

**5.3**




✓ = shape
✓ = labelled axes
✓✓✓✓ = labels on graph

**(6)**

**5.4** $\Delta H = H_{reactants} - H_{products}$ ✓

$= 2\,648 - 3\,270$ ✓

$\Delta H = -622\ kJ{\cdot}mol^{-1}$ ✓ (3)

**6. 6.1 6.1.1** 360 kJ·mol$^{-1}$ ✓ (1)

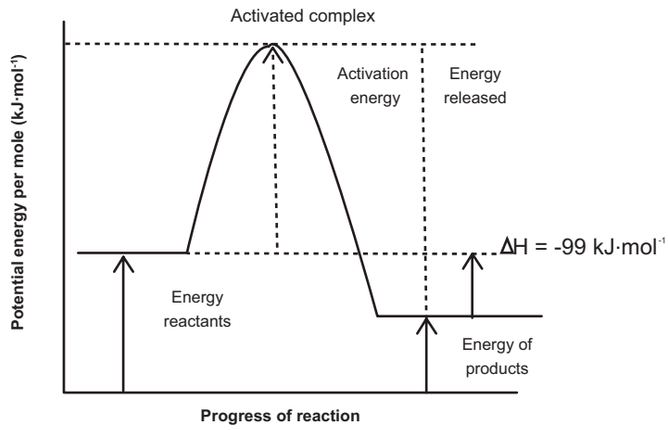
**6.1.2** 120 kJ·mol$^{-1}$ ✓ (1)

**6.1.3** 360 kJ·mol$^{-1}$ ✓ (1)

**6.1.4** 240 kJ·mol$^{-1}$ ✓ (1)

**6.2** Endothermic ✓. The products are at higher energy than the reactants,✓ and energy was thus absorbed.✓ (3)

**7.**




✓ = shape

✓ = labelled axes

✓✓✓✓ = labels on graph

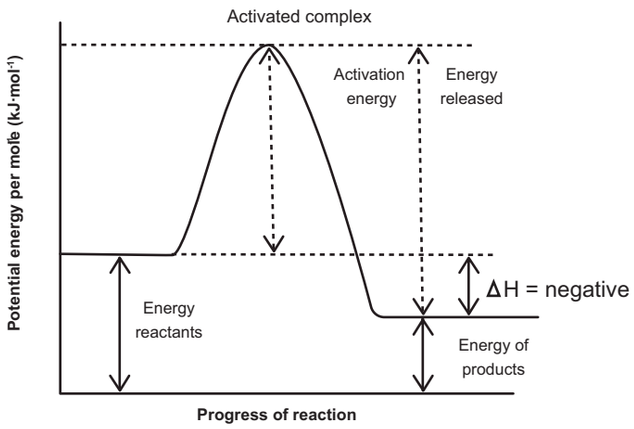
**(6)**

**8. 8.1 8.1.1**

| | **Dissolving NaOH in water** | **Dissolving $NH_4NO_3$ in water** |
|---|---|---|
| Exothermic or endothermic | Exothermic ✓ | Endothermic ✓ |
| Energy levels of reactants and products | Energy of reactants higher than energy of products ✓ | Energy of products higher than energy of reactants ✓ |
| ΔH ( positive or negative) | ΔH = negative (-) ✓ | ΔH = positive (+) ✓ (6) |

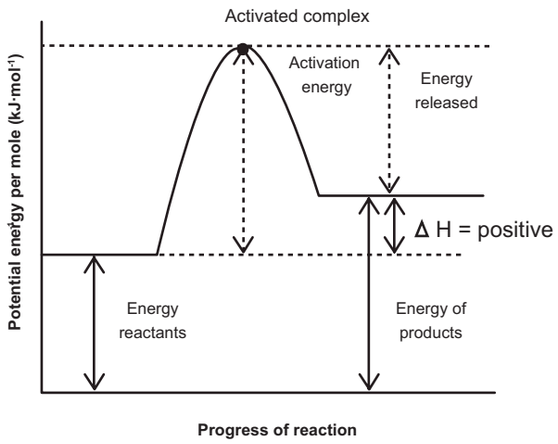
**8.2.**

**Exothermic reaction**




(4)

**Endothermic reaction**




**(4)**

## CONSOLIDATION EXERCISE

**[56 MARKS]**

### MULTIPLE CHOICE

**1.** B ✓✓ (2)

**2.** D ✓✓ (2)

**3.** A ✓✓ (2)

### LONG QUESTIONS

**4.** **4.1** Total energy of the solution is greater ✓ as there is excess energy in the system due to the dissolving of the NaOH releasing excess energy into the system. ✓ (2)

**4.2** Exothermic ✓ (1)

**5.** **5.1** **5.1.1** D ✓✓ (2)

**5.1.2** C ✓✓ (2)

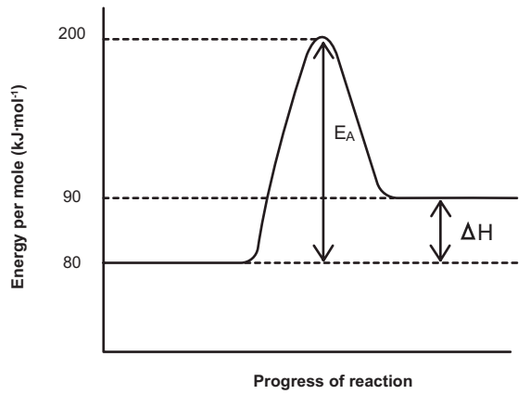
**5.1.3** B – A ✓✓ (2)

**5.1.4** B – D ✓✓ (2)

**5.2** **5.2.1** The minimum energy required to start a chemical reaction. ✓✓ (2)

**5.2.2** The position on the graph representing the transition point between reactants and products where the old bonds are breaking ✓ and the new bonds are forming. ✓ (2)

**6.** **6.1**




✓ = shape
✓ = labelled axes
✓✓= labels (ΔH and $E_A$)
✓ = correct values on the y-axis

(5)

**6.2** Endothermic.✓ The energy of the products is higher than the energy of the reactants. ✓ (2)

**6.3** ALTERNATIVE 1

$\Delta H = H_{released} - E_A$ ✓

$= (200 - 90) - (200 - 80)$ ✓

ALTERNATIVE 2

$\Delta H = E_{products} - E_{reactants}$

$= 90 - 80$

$= 10\ kJ \cdot mol^{-1}$ ✓

**6.4** The activation energy represents the minimum amount of energy that is needed to be added to the system ✓ to ensure that successful/effective collisions take place.✓ (2)

**7.** **7.1** approximately 25 $kJ \cdot mol^{-1}$ ✓✓ (2)

**7.2** approximately 35 $kJ \cdot mol^{-1}$ ✓✓ (2)

**7.3** Exothermic. ✓ The energy of the products is less than the energy of the reactants.✓ (2)

**7.4** B – C . ✓More energy is released during bond formation of BC than was required to break AB. ✓✓ (3)

**8.** 8.1 Endothermic. ✓ Heat is being added to reactants to keep reaction going. ✓ (2)

**8.2** Exothermic. ✓ Heat is being released after product formation. ✓ (2)

**9.** **9.1** A: It would be warm in your hands. ✓ Energy is released to the surroundings therefore the temperature increases. ✓ (2)

B: It would be cold in your hands. ✓ Energy is absorbed from the surroundings therefore the temperature decreases. ✓ (2)

**9.2** Reaction B is endothermic. ✓ (1)

**9.3** It means that energy is absorbed from the surroundings.✓✓ (Energy of the products is greater than the energy of the reactants.) (2)

# Topic 13: Types of Reactions

## WORKSHEET QUESTIONS

### MULTIPLE CHOICE

**1.** A redox reaction is a reaction in which ...

**A** both electron and proton transfer take place.

**B** neither electron nor proton transfer take place.

**C** only proton transfer takes place.

**D** only electron transfer takes place. (2)

**2.** Consider the reaction: $Pb(s) + Cu^{2+}(aq) \rightarrow Pb^{2+}(aq) + Cu(s)$
The oxidised product is ...

**A** Pb (lead).

**B** $Pb^{2+}$ (lead ions).

**C** Cu (copper).

**D** $Cu^{2+}$ (copper ions). (2)

**3.** In the same reaction as in **2.** above, the oxidising agent is ...

**A** Pb (lead).

**B** $Pb^{2+}$ (lead ions).

**C** Cu (copper).

**D** $Cu^{2+}$ (copper ions). (2)

**4.** In the reaction $Cu + 2Ag^{+} \rightarrow Cu^{2+} + 2Ag$, which of the following statements is true?

**A** $Cu^{2+}$ is the oxidising agent.

**B** $Ag^{+}$ is reduced in the reaction.

**C** Ag is the reducing agent.

**D** Cu is reduced. (2)

**5.** Consider the following acid-base reaction:

$NH_4^+ + CO_3^{2-} \rightarrow NH_3 + HCO_3^-$

In this reaction, $NH_3$ is acting as ...

**A** a base.

**B** an acid.

**C** a conjugate base.

**D** a conjugate acid. (2)

**6.** Consider the following two acid-base reactions as shown by the equations below:

$H_3O^+ (aq) + HCO_3^{2-} (aq) \rightarrow H_2O (l) + H_2CO_3 (aq)$

$HCO_3^- (aq) + OH^- (aq) \rightarrow CO_3^{2-} (aq) + H_2O (l)$

Which of the following substances act as ampholytes in these reactions?

**A** $H_3O^+$ and $H_2O$

**B** $H_3O^+$ and $HCO_3^{2-}$

**C** $HCO_3^{2-}$ and $H_2CO_3$

**D** $HCO_3^{2-}$ and $H_2O$ (2)

## LONG QUESTIONS

### Acids and Bases

**7.** Define an acid and a base according to Arrhenius' theory. (2)

**8.** Define an acid and a base according to the Lowry-Brønsted theory. (2)

**9.** What are conjugate acid-base pairs? (2)

**10.** Identify the conjugate acid-base pairs in the following reactions:

**4.1** $OH^- + HCN \rightarrow H_2O + CN^-$ (2)

**4.2** $PO_4^{3-} + HNO_3 \rightarrow NO_3^- + HPO_4^{2-}$ (2)

**4.3** $HCO_3^- + HCl \rightarrow H_2CO_3 + Cl^-$ (2)

**11.** Copy the following table into your workbook. Using the information that is available in the table, complete the empty spaces.

| Acid | Base | Conjugate acid | Conjugate base | Equation |
|---|---|---|---|---|
| | | $H_2O$ | $ClO_3^-$ | |
| $HSO_4^-$ | $PO_4^{3-}$ | | | |
| | | | | $S^{2-} + H_2O \rightarrow OH^- + HS^-$ |

(10)

**12.** Explain what is meant by the term "ampholytes"? (2)

**13.** $H_2O$ is an ampholyte. Give an equation showing water acting as:

**13.1** a base. (2)

**13.2** an acid. (2)

## Redox reactions

**14.** State whether the following reactions are oxidation or reduction reactions and then identify each of the underlined chemical substances as either oxidising or reducing agents:

**14.1** $\underline{Ag^+} + e^- \rightarrow Ag$ (2)

**14.2** $\underline{SO_4^{2-}} + 4H^+ + 2e^- \rightarrow SO_2 + 2H_2O$ (2)

**14.3** $\underline{NO} + 2H_2O \rightarrow NO_3^- + 4H^+ + 3e^-$ (2)

**15.** Write oxidation numbers for each substance in the following unbalanced equations, and then use these oxidation numbers to answer these questions for each reaction.

- Identify and link the species that undergo changes in oxidation numbers.
- Write down the oxidation and reduction half reactions.
- Write down the net electrochemical (Redox) reaction.
- Identify the oxidising and reducing agents in each reaction.

**15.1** $K + Br_2 \rightarrow KBr$ (8)

**15.2** $LiCl + F_2 \rightarrow LiF + Cl_2$ (8)

**15.3** $Ca + PbSO_4 \rightarrow CaSO_4 + Pb$ (8)

**15.4** $Zn + AgNO_3 \rightarrow Zn(NO_3)_2 + Ag$ (8)

**16.** Balance the following REDOX reactions using the ion-electron method:

**3.1** $K + Ca^{2+} \rightarrow K^+ + Ca$ (6)

**3.2** $Al + Fe(NO_3)_2 \rightarrow Al(NO_3)_3 + Fe$ (6)

## CONSOLIDATION QUESTIONS [72 MARKS]

**1.** Consider the reaction: $2Al + 3Cu^{2+} \rightarrow 2Al^{3+} + 3Cu$
In this reaction, electrons are transferred from ...

**A** Al to $Al^{3+}$

**B** Cu to $Cu^{2+}$

**C** Al to $Cu^{2+}$

**D** Cu to $Al^{3+}$ (2)

**2.** The balanced chemical equation below shows the reaction between $H_2S$ gas and an acidified solution of $Cr_2O_7^{2-}$.

$3H_2S(g) + Cr_2O^{2-}(aq) + 8H^+(aq) \rightarrow 3S(s) + 2Cr^{3+}(aq) + H_2O(\ell)$

Which substance is the reducing agent?

**A** $Cr_2O_7^{2-}$

**B** $H_2S$

**C** S

**D** $Cr^{3+}$ (2)

**3.** Which are the two acids in the following reaction?

$HSO_4^- + OH^- \rightarrow H_2O + SO_4^{2-}$

**A** $HSO_4^-$ and $OH^-$

**B** $HSO_4^-$ and $H_2O$

**C** $H_2O$ and $OH^-$

**D** $HSO_4^-$ and $SO_4^{2-}$ (2)

**4.** Ethanoic acid can be regarded as a weak acid because it ...

**A** can only react with a strong base.

**B** partially ionises to produce a low concentration of hydronium ions.

**C** can only react with weak bases.

**D** it has a large amount of water mixed with it. (2)

**5.** Which of the following is NOT a conjugate acid-base pair?

**A** HCl and $Cl^-$

**B** $HCO_3^-$ and $H_2CO_3$

**C** $HSO_4^-$ and $H_2SO_4$

**D** $OH^-$ and $H_3O^+$ (2)

## LONG QUESTIONS

**6.** Define the following

**1.1** Oxidation (1)

**1.2** Reducing agent (2)

**1.3** Oxidation number (2)

**7.** Assign oxidation numbers to the atoms in the following molecules.

Chlorine in $Cl_2$, $ClF_3$, $Cl_2O$ and HOCl (4)

Copper in $CuCl_2$, $Cu_2O$, $Cu_3(PO_4)_2$ (3)

**8.** Write oxidation numbers for each substance in the following unbalanced equations, and then use these oxidation numbers to answer these questions for each reaction.

- Identify and link the species that undergo changes in oxidation numbers.
- Write down the oxidation and reduction half reactions.
- Write down the net electrochemical (Redox) reaction.
- Identify the oxidising and reducing agents in each reaction.

**8.1** $Ca + PbSO_4 \rightarrow CaSO_4 + Pb$ (8)

**8.2** $Zn + AgNO_3 \rightarrow Zn(NO_3)_2 + Ag$ (8)

**9.** Balance the following REDOX reactions using the ion-electron method

**9.1** $Fe^{2+} + Pt^{2+} \rightarrow Fe^{3+} + Pt$ (6)

**9.2** $K + Al(NO_3)_3 \rightarrow KNO_3 + Al$ (3)

### Acids and Bases

**10.** Explain the meaning of the following terms:

**10.1** Ionisation (2)

**10.2** Dissociation (2)

**10.3** Protolysis (2)

**10.4** Polyprotic acid (2)

**11.** When sulfuric acid dissolves in water, it ionises in two steps as follows:

Step 1: $H_2SO_4 + H_2O \rightarrow H_3O^+ + HSO_4^-$

Step 2: $HSO_4^- + H_2O \rightarrow H_3O^+ + SO_4^{2-}$

**11.1** Define an acid according to the Lowry-Brønsted theory. (1)

**11.2** One of the substances is an ampholyte. Write down its formula and explain why it is an ampholyte. (2)

**11.3** Identify the conjugate acid-base pairs in step 2 of the reaction. (2)

**11.4** Write balanced equations for the reactions between sulfuric acid and the following substances:

**11.4.1** potassium hydroxide solution. (3)

**11.4.2** copper oxide powder. (3)

**11.4.3** sodium carbonate powder. (3)

# WORKSHEET MEMORANDUM

## MULTIPLE CHOICE

**1.** D ✓✓ (2)

**2.** B ✓✓ (2)

**3.** D ✓✓ (2)

**4.** B ✓✓ (2)

**5.** C ✓✓ (2)

**6.** D ✓✓ (2)

## LONG QUESTIONS

### Acids and Bases

**7.** Acid: Substances that produce hydrogen ions in solution ($H^+$). ✓ (1)

Bases: Substances that produce hydroxide ($OH^-$) ions in solution. ✓ (1)

**8.** Acid: Substances that are proton donors.✓ (1)

Bases: are substances that are proton acceptors.✓ (1)

**9.** These are pairs of acids and bases that differ from each other by one proton in a protolytic reaction. ✓✓ (2)

**10.** **10.1** $HCN$ and $CN^-$
Acid 1 Conjugate base 1✓
$OH^-$ and $H_2O$
Base 2 Conjugate acid 2✓ (2)

**10.2** $HNO_3$ and $NO_3^-$
Acid 1 Conjugate base 1✓
$PO_4^{3-}$ and $HPO_4^{2-}$
Base 2 Conjugate acid 2✓ (2)

**10.3** $HCl$ and $Cl^-$
Acid 1 Conjugate base 1✓
$HCO_3^-$ and $H_2CO_3$
Base 2 Conjugate acid 2✓ (2)

**11.**

| Acid | Base | Conjugate acid | Conjugate base | Equation |
|---|---|---|---|---|
| $HClO_3$ ✓ | $OH^-$ ✓ | $H_2O$ | $ClO_3^-$ | $HClO_3 + OH^- \rightarrow ClO_3^- + H_2O$ |
| $HSO_4^-$ | $PO_4^{3-}$ | $HPO_4^{3-}$ ✓ | $SO_4^{2-}$ ✓ | $HSO_4^- + PO_4^{3-} \rightarrow SO_4^{2-} + HPO_4^{2-}$ ✓ |
| $H_2O$ ✓ | $S^{2-}$ ✓ | $HS^-$ ✓ | $OH^-$ ✓ | $S^{2-} + H_2O \rightarrow OH^- + S^-$ |

(10)

**12.** A substance that is able to act as both an acid or a base in an acid-base reaction ✓✓ (2)

**13.** **13.1** $HCl + H_2O \rightarrow H_3O^+ + Cl^-$ (✓ ✓) (2)

**7.2** $NH_3 + H_2O \rightarrow NH_4^+ + OH^-$ (✓ ✓) (2)

## Redox reactions

**14.** **14.1** Reduction ✓

$Ag^+$ is an oxidising agent ✓ (2)

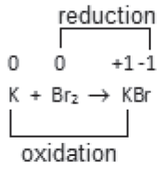
**14.2** Reduction ✓

$SO_4^{2-}$ is an oxidising agent ✓ (2)

**14.3** Oxidation ✓

NO is a reducing agent ✓ (2)

**15.** **15.1**



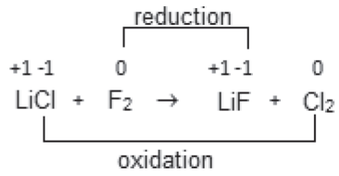

✓✓

Oxidation: $K \rightarrow K^+ + e^-$ ✓ Reducing agent = K ✓

Reduction: $Br_2 + 2e^- \rightarrow 2Br^-$ ✓ Oxidising agent = $Br_2$ ✓

Net reaction: $2K + Br_2 \rightarrow 2K^+ + 2Br^-$ ✓✓ (8)

**15.2**



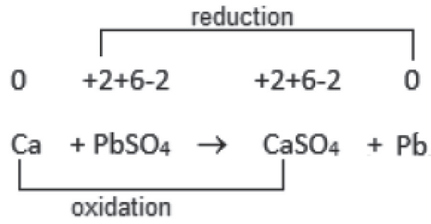

✓✓

Oxidation: $2Cl^- \rightarrow Cl_2 + 2e^-$ ✓ Reducing agent = $Cl^-$✓

Reduction: $F2 + 2e^- \rightarrow 2F$-✓ Oxidising agent = $F_2$ ✓

Net reaction: $2Cl^- + F_2 \rightarrow 2F^- + Cl_2$ ✓✓ (8)

**15.3**

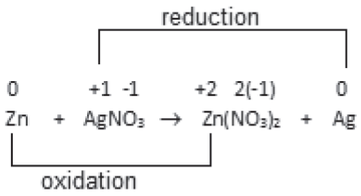



Oxidation: $Ca \rightarrow Ca^{2+} + 2e^-$✓ Reducing agent = Ca ✓

Reduction: $Pb^{2+} + 2e^- \rightarrow Pb$ ✓ Oxidising agent = $Pb^{2+}$✓

Net reaction: $Ca + PbSO_4 \rightarrow CaSO_4 + Pb$ ✓✓ (8)

**15.4**



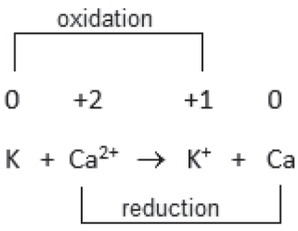

✓✓

Oxidation: $Zn \rightarrow Zn^{2+} + 2e^-$ ✓ Reducing agent = Zn ✓

Reduction: $Ag^+ + e^- \rightarrow Ag$ ✓ Oxidising agent = $Ag^+$ ✓

Net reaction: $Zn + 2Ag^+ \rightarrow Zn^{2+} + 2Ag$ ✓✓

**16. 16.1**



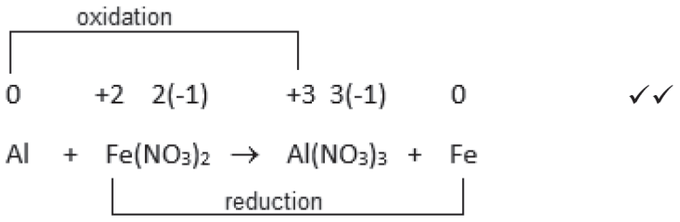

✓✓

Oxidation: $K \rightarrow K^+ + e^-$ ✓

Reduction: $Ca^{2+} + 2e^- \rightarrow Ca$ ✓

Net reaction: $2K + Ca^{2+} \rightarrow 2K^+ + Ca$ ✓✓ (6)

**16.2**




✓✓

Oxidation: $Al \rightarrow Al^{3+} + 3e^-$ ✓

Reduction: $Fe^{2+} + 2e^- \rightarrow Fe$ ✓

Net reaction: $2Al + 3Fe^{2+} \rightarrow 2Al^{3+} + 3Fe$ ✓✓ (6)

## CONSOLIDATION EXERCISE

**[72 MARKS]**

## MULTIPLE CHOICE

**1.** C ✓✓ (2)

**2.** B ✓✓ (2)

**3.** B ✓✓ (2)

**4.** B ✓✓ (2)

**5.** D ✓✓ (2)

## LONG QUESTIONS

### Redox reactions

**6.** **6.1** The process whereby electrons are lost in a reaction. ✓ (1)

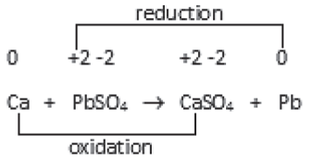
**6.2** A substance that will assist the reduction process by itself undergoing oxidation. ✓✓ (2)

**6.3** The oxidation number of an element is a number assigned to each element in a compound in order to keep track of the electrons during a reaction. ✓✓ (2)

**7.** **7.1** $Cl_2 = 0$ ✓ $ClF_3 = +3$ ✓ $Cl_2O = -1$ ✓ $HOCl = -1$ ✓ (4)

**7.2** $CuCl_2 = +2$ ✓ $Cu_2O = +1$ ✓ $Cu_3(PO_4)_2 = +2$ ✓ (3)

**8.** **8.1**



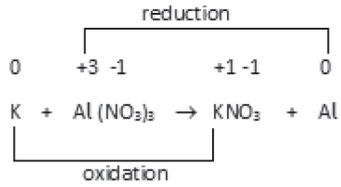

✓✓

Oxidation: $Ca \rightarrow Ca^{2+} + 2e^-$ ✓ Reducing agent = Ca ✓

Reduction: $Pb^{2+} + 2e^- \rightarrow Pb$ ✓ Oxidising agent = $Pb^{2+}$ ✓

Net reaction: $Ca + Pb^{2+} \rightarrow Ca^{2+} + Pb$ ✓✓ (8)

**8.2**



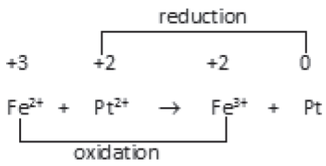

✓✓

Oxidation: $K \rightarrow K^+ + e^-$ ✓ Reducing agent = K ✓

Reduction: $Al^{3+} + 3e^- \; Al$ ✓ Oxidising agent = $Al^{3+}$ ✓

Net reaction: $3K + Al^{3+} \rightarrow 3K^+ + Al$ ✓✓ (8)

**9. 9.1**



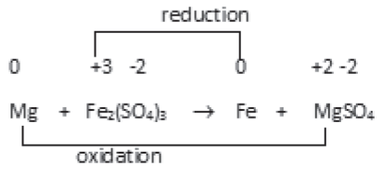

✓✓

Oxidation: $Fe^{2+} \rightarrow Fe^{3+} + e^-$ ✓

Reduction: $Pt^{2+} + 2e^- \rightarrow Pt$ ✓

Net reaction: $2Fe^{2+} + Pt^{2+} \rightarrow 2Fe^{3+} + Pt$ ✓✓ (6)

**9.2**




✓✓

Oxidation: $Mg \rightarrow Mg^{2+} + 2e^-$ ✓

Reduction: $Fe^{3+} + 3e^- \rightarrow Fe$ ✓

Net reaction: $3Mg + 2Fe^{3+} \rightarrow 3Mg^{2+} + 2Fe$ ✓✓ (6)

## Acids and Bases

**10. 10.1** When a molecular substance dissolves in water to form aqueous ions for the first time. ✓ (2)

**10.2** When an already ionic substance dissolves in water to form aqueous ions. ✓✓ (2)

**10.3** The name given to the acid-base reaction that involves the simultaneous exchange of protons between acidic and basic substances. ✓✓ (2)

**10.4** An acid that is able to release more than one proton upon ionisation. ✓✓ (2)

**11. 11.1** Substance that is a proton donor. ✓ (1)

**11.2** $HSO_4^-$ ✓

$HSO_4^-$ is the ion formed when the acid $H_2SO_4$ ionises in the first step.

In this case $HSO_4^{--}$ is the conjugate base of $H_2SO_4$. ✓ $HSO_4^-$ will ionise further to form $SO_4^{2-}$ thus acting as an acid. ✓ This makes it an ampholyte. ✓ (2)

**11.3** $HSO_4^-$ and $SO_4^{2-}$ ✓
acid 1 conjugate base 1

$H_2O$ and $H_3O^+$ ✓ (2)
base 2 conjugate acid 2

**11.4 2.4.1** $H_2SO_4 + 2KOH \rightarrow K_2SO_4 + 2H_2O$
✓ ✓ ✓ balancing (3)

**2.4.2** $H_2SO_4 + CuO \rightarrow CuSO_4 + H_2O$
✓ ✓ ✓ balancing (3)

**2.4.3** $H_2SO_4 + Na_2CO_3 \rightarrow Na_2SO_4 + CO_2 + H_2O$
✓ ✓ ✓ balancing (3)

# ASSESSMENTS

# Topic 9: Electrosttics

## QUESTIONS

### MULTIPLE CHOICE QUESTIONS

1. Conducting sphere A carries a charge of +2 nC and conducting sphere B carries a charge of +10 nC. They are brought together and touch and then are separated again. Which one of the following statements is true?
   A During contact, –4 nC of charge is transferred from sphere A to B.
   B During contact, +4 nC of charge are transferred from sphere A to B.
   C During contact, –4 nC of charge is transferred from sphere B to A.
   D During contact, +4 nC of charge is transferred from sphere B to A. (2)

2. Three point charges of magnitudes –3 μC, +3 μC and +2 μC are placed at the three corners of a right angled triangle as indicated in the diagram.

   –3 μC ●

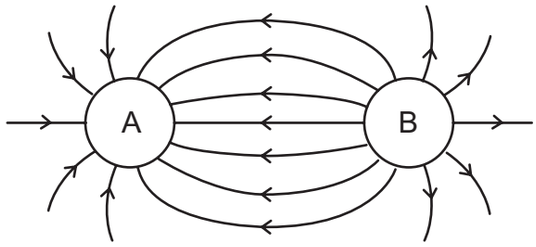
   +2 μC ●  ● +3 μC

   Which one of the following best represents the direction of the resultant force exerted on the +2 μC charge by the other two charges?

   A. ↑  B. ←  C. ↗  D. ↖ (2)

3. The force of repulsion between two positive conducting spheres with charges of 2Q and 6Q separated by a distance, *r*, is *F*. The spheres are momentarily touched and then separated to a distance of 2*r*. What will the new force between the charges be?
   A $\frac{1}{4}F$
   B $\frac{1}{3}F$
   C $F$
   D $\frac{4}{3}F$ (2)

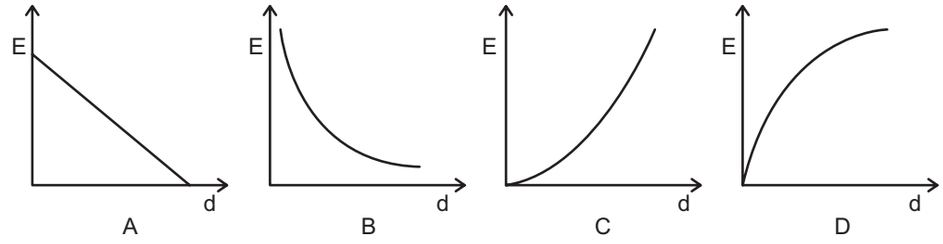
4. The electric field pattern between two charged spheres, **A** and **B**, is shown below.




Which ONE of the following statements regarding the charge on spheres **A** and **B** is CORRECT?

A Spheres **A** and **B** are both positively charged.
B Spheres **A** and **B** are both negatively charged.
C Sphere **A** is positively charged and sphere **B** is negatively charged.
D Sphere **A** is negatively charged and sphere **B** is positively charged. (2)

5. Which of the following sketch graphs best represents the relationship between the electric field strength **E** and the distance **d** from a given charge **Q**?




(2)

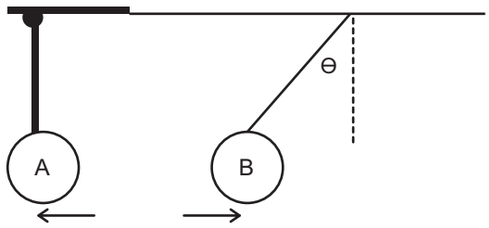
6. At a distance $d$ from a point charge $Q$ the electric field strength is $E$. What will be the electric field strength at a distance $\frac{1}{2}d$ from the charge $Q$?

A $8E$
B $E$
C $2E$
D $4E$ (2)

## LONG QUESTIONS

7. Two identical plastic balls (each with a weight of 0,49 N) are set up as shown below so that one is **fixed** vertically but can slide horizontally (A) and one is hanging from a strong thread (B). Ball B has a fixed negative charge but ball A is able to have its positive charge varied.

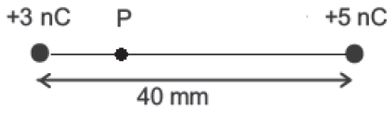
   A learner wants to find the relationship between the product of the charges and the force of attraction. He varies the charge on the fixed ball A and then measures the angle (θ) of the thread to the vertical, while adjusting the distance between the balls so that it is always 3,7 cm. Using simple trigonometry, he calculates the horizontal electrostatic force of attraction using this angle ($F_h$ = 0,49 tan θ). The results are tabulated below.




| Charge on ball A (nC) (+) | Angle to vertical (°) | Force of attraction = 0,49 tanθ (x $10^{-2}$ N) |
|---|---|---|
| 10 | 5,0 | 4,3 |
| 20 | 9,5 | 8,2 |
| 30 | 14,8 | 12,9 |
| 40 | 19,4 | 17,3 |
| 50 | 23,5 | **X** |
| 60 | 27,7 | 25,7 |

7.1 Write a hypothesis for this investigation. (3)
7.2 Calculate the missing value, **X**. (2)
7.3 What is the independent variable in this experiment? (1)
7.4 Give two controlled (fixed) variables in this experiment. (2)
7.5 Draw a fully labelled free body diagram for the forces acting on B. (3)
7.6 What is the relationship between the charge on ball A and the force of attraction? (1)
[12]

8. Two small conducting spheres which carry charges of +3 nC and +5 nC respectively, are placed a distance of 40 mm apart as shown in the diagram below.




8.1 Define an electric field. (2)

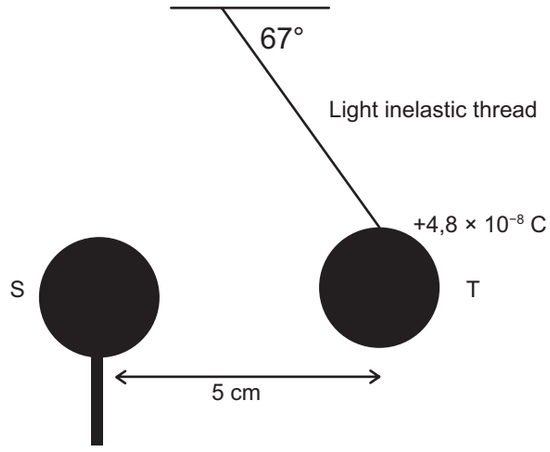
8.2 Draw the electric field that is set up by these two small conducting spheres. Show the conducting spheres as small circles. (3)

8.3 Along the line joining the two small spheres, there is a point P, which is 10 mm from the +3 nC charge. Show that the magnitude of the resultant or net electric field strength at P is $2{,}2 \times 10^5$ N·C$^{-1}$. (8)

8.4 An electron is placed at point P. Calculate the force experienced by the electron due to the net electric field. (4)

[17]

9. Tshepo and Mary suspend a graphite-coated polystyrene sphere T from the ceiling by means of a very light inelastic thread. The sphere carries a charge of $+4,8 \times 10^{-8}$ C and has a mass of 1,99 g. Tshepo now brings an insulated stand, on which an **identically charged** sphere S is mounted, close to sphere T. Sphere T settles in an equilibrium position so that the centres of the spheres are 5 cm apart, as indicated in the diagram.




9.1 Briefly explain why the polystyrene spheres need to be coated with graphite. (1)

9.2 Define the magnitude of the electric field at a point. (2)

9.3 Draw the electric field lines around sphere S. (3)

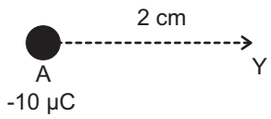
9.4 Draw a free body of the forces acting on sphere T. (4)

9.5 Calculate the **magnitude** and **direction** of the electrostatic force that sphere S exerts on sphere T. (3)

9.6 Calculate the magnitude of the electric field strength at S. (3)

[16]

10. A charged sphere (A) holding a charge of −10 μC, is held fixed in position on a horizontal, insulated surface.

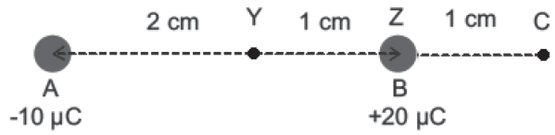



10.1 What is meant by the term 'electric field'? (2)

10.2 How many electrons were lost or gained in order for sphere A to gain its charge? (2)

10.3 Calculate the magnitude and direction of the electric field strength at position Y, 2 cm away from the point charge A. (4)

A second point charge (B) holding a charge of +20 μC, is placed at position Z, 1 cm to the right of Y, on the horizontal, insulated surface and it is free to move.




10.4 Draw the electric field lines that represent the resultant electric field that is set up by the two point charges A and B. (3)

10.5 State *Coulomb's law*. (2)

10.6 Calculate the electrostatic force that B will experience due to A. (4)

10.7 In order to prevent B from moving, a third point charge (C) is placed 1 cm to the right of B. Calculate the charge that must be placed on C in order to hold B stationary. (4)

[21]

11. A helium nucleus has three types of forces acting within it namely *electrostatic*, *gravitational* and *nuclear forces*. The question that puzzled scientists for a long time was 'What stops the nucleus from falling apart due to the strong electrostatic repulsion between the two protons?'

11.1 Draw a diagram of the electrostatic field between the two protons in the nucleus. (2)

The charge and mass of a proton are $+1{,}6 \times 10^{-19}$ C and $1{,}67 \times 10^{-27}$ kg respectively.
In the helium nucleus the two protons are $8{,}4 \times 10^{-16}$ m apart.

11.2 Calculate the force of electrostatic repulsion between the protons. (3)

11.3 Calculate the force of gravitational attraction between the protons. (3)

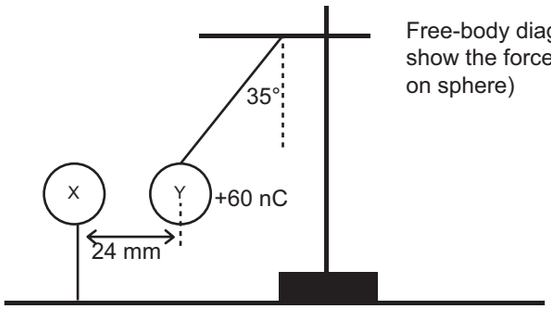
11.4 Is the nuclear force present in the nucleus one of attraction or repulsion? (1)

11.5 By how many powers of ten do the electrostatic and gravitational forces differ by? (1)

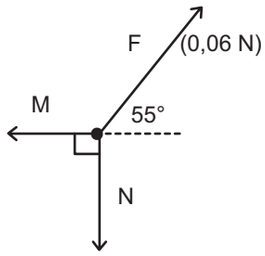
11.6 Which of the three forces has to be the largest? Give a reason for your answer. (2)

[12]

12. Two small charged polystyrene spheres, **X** and **Y**, are in equilibrium as shown in the diagram below. Sphere **X** stands on an insulated pole. Sphere **Y**, which has a charge of +60 nC, is suspended by means of a light inextensible thread. The tension ($F_T$) in the thread is 0,06 N. The angle between the thread and the vertical is 35°. The distance between the centre of sphere **X** and the centre of sphere **Y** is 24 mm.




Free-body diagram to show the forces acting on sphere)




12.1 The free body diagram represents the forces acting on sphere *Y*. Name the forces **M** and **N**. (2)

12.2 Does sphere **X** have a positive OR a negative charge? Give a reason for your answer. (2)

12.3 Calculate the magnitude of the horizontal component of the tension in the thread. Give your answer to 3 decimal places. (2)

12.4 What is the magnitude of force **M**? (1)

12.5 State *Coulomb's Law*. (2)

12.6 Calculate the magnitude of the charge on sphere **X**. (4)

ASSESSMENTS

# MARKING GUIDELINES

## MULTIPLE CHOICE

1. A ✓✓ The negative charge ($e^-$) moves. [CL2] (2)

2. D ✓✓ The +2 μC charge is repelled by the +3 μC (force to the left) and attracted to the -3 μC charge (for up). The resultant is the vector combination of these two. [CL3] (2)

3. B ✓✓ The new charge on each sphere is 4$Q$.
$$\frac{4Q \times 4Q}{4r^2} = \frac{16QQ}{4r^2} = \frac{1}{3} \times \frac{2Q \times 6Q}{r^2}$$ [CL4] (2)

4. D ✓✓ Field lines go from B into A, so B is positive, A is negative. [CL2] (2)

5. B ✓✓ $E = kQ \times \frac{1}{d^2}$; $E$ is inversely proportional to $d^2$. [CL2] (2)

6. D ✓✓ $E = \frac{kQ}{d^2}$ When the distance is halved, the force increases $(2)^2 = 4$ times. [CL2] (2)

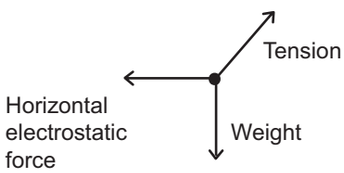
## ANSWERS TO LONG QUESTIONS

7. 7.1 The horizontal force is directly proportional (any relationship) ✓ to the (product of the two charges)/ charge on A ✓ if always measured between the same two balls with a fixed distance of 3,7 cm between them and constant charge on B. ✓ [CL2] (3)

   7.2 $F_g \times \tan\theta = 0{,}49 \tan 23{,}5$ ✓ = 0,21 N ✓ [CL2] (2)

   7.3 Charge on ball A ✓ [CL2] (1)

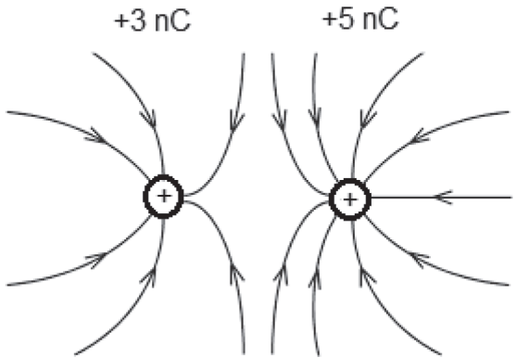
   7.4 Mass of ball B, distance between balls, charge on ball B ✓✓ ANY TWO OF THESE ANSWERS. [CL3] (2)

   7.5


[CL2] (3)

   7.6 They are directly proportional. ✓ [CL2] (1)

8. 8.1. A region in space in which an electric charge ✓ will experience a force ✓ [CL1] (2)
8.2. ✓ direction ✓ general shape ✓ greater density of field lines around +5 nC (3)



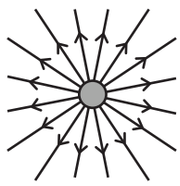

8.3. $E_3 = k\frac{Q}{r^2}$ $= \frac{(9\times10^{9})(3\times10^{-9}\checkmark)}{(10\times10^{-3}\checkmark)^2}$ = 270 000 N·C$^{-1}$ ✓ right

$E_5 = k\frac{Q}{r^2}$ $= \frac{(9\times10^{9})(5\times10-^{9}\checkmark)}{(30\times10^{-3}\checkmark)^2}$ = 50 000 N.C$^{-1}$ ✓ left

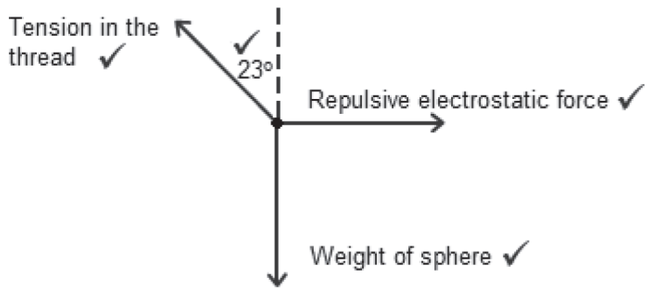
$E_{net}$ = 270 000 – 50 000 ✓ (towards the right – positive direction)
= 220 000 N·C$^{-1}$ ✓ [CL3] (8)

8.4 $F = qE$ = $(1{,}6\times10^{-19}\checkmark)(220\,000)$ ✓
= $3{,}52\times10^{-14}$ N ✓ towards the +3nC charge ✓ [CL2] (4)

9. 9.1 Graphite is a conductor of electric charge; this allows the charge to be held and spread evenly around the sphere. [CL4] (1)
9.2 The force per unit positive charge. ✓✓ [CL1] (2)
9.3 Radial lines ✓ arrows pointing away ✓ even distribution ✓ [CL1] (3)



9.4 diagram ✓




[CL2] (4)

ASSESSMENTS

9.5 ALTERNATIVE 1

Weight = $mg$ = 0,00199 × 9,8 = 1,95 × $10^{-2}$ N✓

$\tan 23° = \frac{F}{0,0195}$✓

$F = 8,29 \times 10^{-3}$ $N$ away from S✓ [CL 2] (3)

ALTERNATIVE 2

$F = k\frac{Q_1 Q_2}{r^2}$✓

$= (9 \times 10^9)\frac{(4,8 \times 10^2)(4,8 \times 10^2)}{(0,05)^2}$✓

$= 8,29 \times 10^{-3}$ $N$ away from S✓ [CL 2] (3)

9.6 $E = \frac{F}{q}$✓ $= \frac{8,29 \times 10^{-3}}{4,8 \times 10^{-8}}$✓ $= 172\,708$ N·C$^{-1}$✓ [CL 3] (3)

10.1 A region of space in which an electric charge experiences an electrostatic force.✓✓ [CL1] (2)

10.2 $n = \frac{Q_A}{e}$

$n = \frac{(10 \times 10^{-6})}{(1,6 \times 10^{-19})}$ ✓

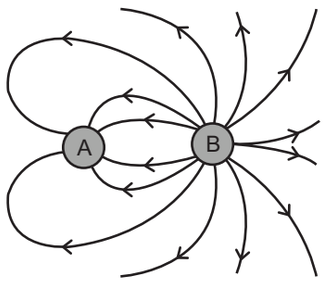
$n = 6,25 \times 10^{13}$ ✓ electrons are gained [CL3] (2)

10.3 $E = \frac{kQ_A}{r^2}$

$E = \frac{(9 \times 10^9)(10 \times 10^{-6})}{(2 \times 10^{-2})^2}$ ✓✓

$E = 2,25 \times 10^8$ N·C$^{-1}$ ✓ left/toward A ✓ [CL3] (4)

10.4




Direction✓
Shape✓
More field lines on B than A✓
[CL3] (3)

10.5 The force between two charges is directly proportional to the product of the charges and inversely proportional to the distance between the charges squared.✓✓ [CL1] (2)

10.6 $F = \frac{kQ_A Q_B}{r^2}$

$F = \frac{(9 \times 10^9)(10 \times 10^{-6})(20 \times 10^{-6})}{(3 \times 10^{-2})^2}$ ✓✓

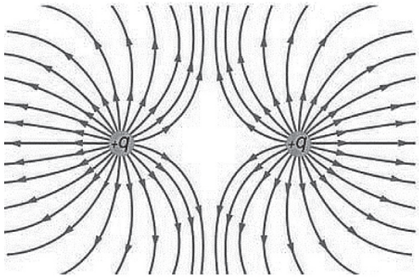
$F = 2\,000$ N ✓ left ✓ [CL2] (4)

10.7 $F = \frac{kQ_BQ_C}{r^2}$

$(2\,000)\checkmark = \frac{(9\times10^{9})(20\times10^{-6})Q_C}{(1\times10^{-2})^2}$ ✓✓

$Q_C = -1,11\times10^{-6}$ C ✓ [CL4] (4)

11. 11.1 direction ✓ shape ✓




[CL2] (2)

11.2. $F = \frac{kQ_1Q_2}{r^2}$

$= \frac{(9\times10^{9})\times(1,6\times10^{-19})^2\checkmark}{(8,4\times10^{-16})^2\checkmark}$

= 3,27 × 10² N ✓ [CL2] (3)

11.3. $F_g = \frac{Gm_1m_2}{r^2} = \frac{6,7\times10^{-11}\times(1,67\times10^{-27})^2\checkmark}{(8,4\times10^{-16})^2\checkmark}$

= 2,65 × $10^{-34}$ N ✓ [CL2] (3)

11.4. Attraction ✓ [CL3] (1)

11.5. 2-(-34) = 36 powers of ten ✓ [CL3] (1)

11.6 As the nucleus is stable and the situation is in equilibrium, the nuclear force is the strongest force. ✓ It overcomes the electrostatic force of repulsion and binds the two protons together in the nucleus. ✓ [CL4] (2)

12. 12.1 M = electrostatic force (of attraction) ✓
N = gravitational force (weight) ✓ [CL2] (2)

12.2 Negative.✓ Y is attracted to X. ✓ [CL3] (2)

12.3 $F_x$ = 0,06 cos 55° ✓
= 0,034 N ✓ [CL3] (2)

12.4 0,034 N✓ **(c.o.e)** [CL2] (1)

12.5 The force between two charges is directly proportional to the product of the charges and inversely proportional to the distance between the charges squared. ✓✓ [CL1] (2)

12.6 $F = \frac{(k\,Q_1Q_2)\checkmark}{r^2}$

$0,034 = \frac{(9\times10^{9})\times(60\times10^{-9})^2\checkmark}{(0,024)^2\checkmark}\times Q_2$

$Q_2$ = 3,63 × $10^{-8}$ C ✓ [CL3] (4)

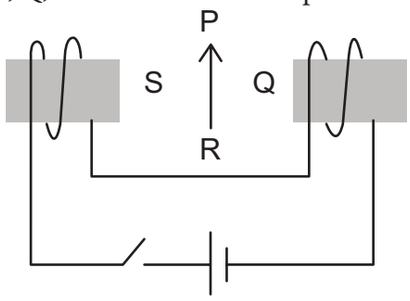
# Topic 10: Electromagnetism

## QUESTIONS

### MULTIPLE CHOICE QUESTIONS

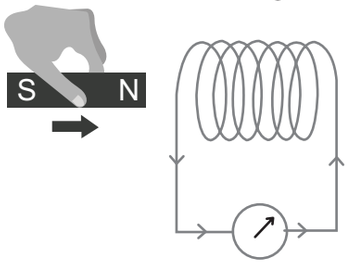
1. The diagram below shows a compass needle placed between the poles of an electromagnet. The north pole of the compass needle is initially at P. If the switch is closed, to which of P, Q, R or S will the north pole of the needle point?

A P
B Q
C R
D S




(2)

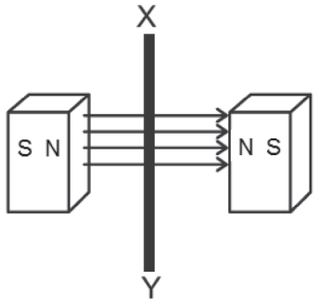
2. An experiment is conducted to investigate the effect of a magnet on a solenoid. As shown in the diagram, the magnet is pushed towards the solenoid and the meter connected to it shows a deflection to the right.




The deflection when the magnet is pulled away from the solenoid (to the left), at a greater speed is ...

A to the right with a greater deflection.
B to the right with a smaller deflection.
C to the left with a greater deflection.
D to the left with a smaller deflection. (2)

3. A conducting wire, **XY**, moves between two magnets as shown below. Which ONE of the following actions can lead to an increased induced current in wire **XY**?




Move the wire…

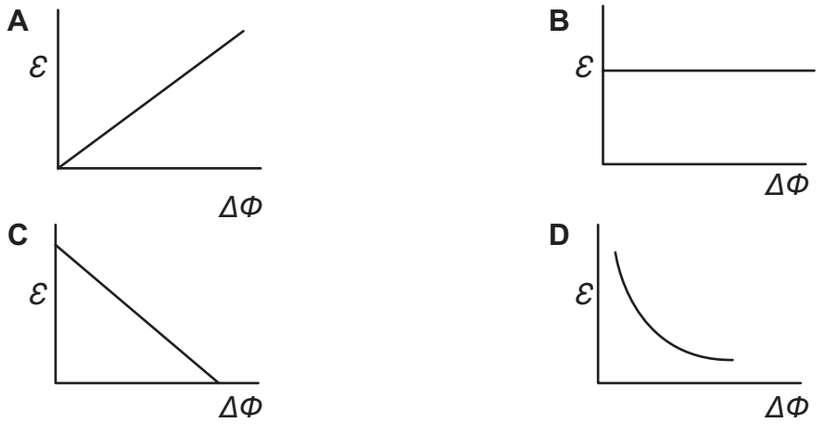
A quickly and parallel to the magnetic field.
B slowly and parallel to the magnetic field.
C quickly and perpendicular to the magnetic field.
D slowly and perpendicular to the magnetic field. (2)

4. Which one of the following correctly defines magnetic flux linkage?
   A The strength of the magnetic field.
   B The rate at which the magnetic field changes.
   C The product of the area of the coil and the magnetic field strength.
   D The product of the magnetic field and the effective area of the coil. perpendicular to the magnetic field. (2)

5. In which of the following situations will the magnetic flux linkage be the greatest? (2)

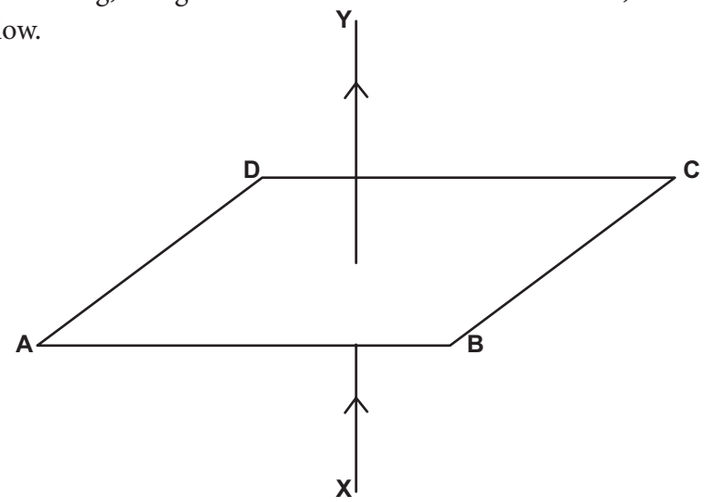
| | Area (cm²) | Magnetic field (T) | Angle of normal to plane of coil and magnetic field (°) |
|---|---|---|---|
| A | 10 | 0,0 | 0 |
| B | 10 | 1,5 | 0 |
| C | 10 | 1,5 | 90 |
| D | 10 | 0,0 | 90 |

6. Which one of the following graphs best gives the relationship between the induced emf ε and the change in magnetic flux ΔΦ? (2)



## LONG QUESTIONS

7. The current in a long, straight vertical wire is in the direction XY, as shown in the diagram below.




7.1 Sketch the pattern of the magnetic flux in the horizontal plane ABCD due to the current-carrying wire. Draw at least **four** flux lines. (3)

7.2 Describe the rule you used to predict the direction of the magnetic field. (2)

7.3 In the situation above, there is a magnetic field and an electrical field.

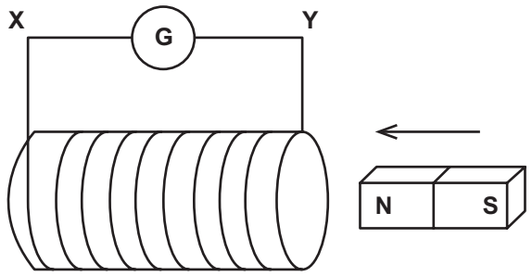
7.3.1 What is the angle between the fields? (2)

7.3.2 What does the electric field do? (2)

7.3.3 What can the magnetic field be used for? (2)

[11]

8. Consider the diagram below in which a bar magnet is moved towards a coil of wire connected to a galvanometer.




8.1 State Faraday's law. (2)

8.2 Write down the equation that governs Faraday's law. (2)

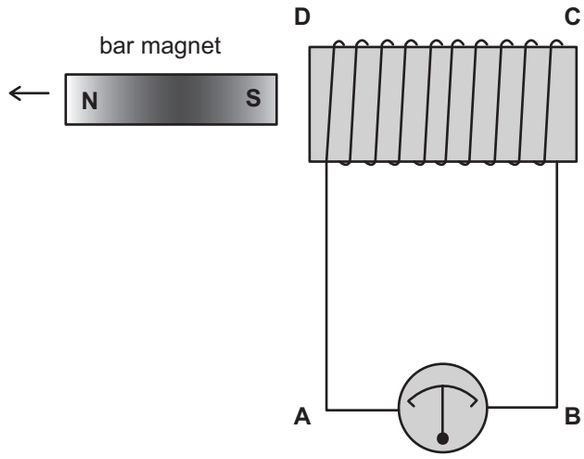
8.3 Predict the direction of the induced current **through the galvanometer** in the above diagram. Write X to Y **or** Y to X. (2)

8.4 What in the equation of Faraday's law enabled you to make this prediction? Explain your answer. (3)

8.5 Give one way to increase the induced emf in the situation above. (1)

[10]

9. The sketch below shows a permanent magnet being **pulled out** of a solenoid in the direction shown. The solenoid is connected to a sensitive galvanometer.




9.1 State Faraday's law. (2)

9.2 State the direction of the induced current through the galvanometer (A to B or B to A)? (1)

9.3 If the magnet is now pushed into the coil and then held stationary inside the coil, describe fully what would you observe on the galvanometer. (3)

9.4 If the magnet is pushed quickly into the coil, what would you observe on the galvanometer? (1)

9.5 What would be the effect of doubling the number of turns in the solenoid on your answer to 9.4? (2)

9.5 Briefly describe how you would produce an alternating current in the solenoid. (2)

[11]

10. Almost all electricity generated in South Africa comes from generators. Generators work on the principle of Faraday's law of electromagnetic induction.

10.1 Write down Faraday's law in words. (2)

10.2 Write down the equation that governs Faraday's law. (2)

10.3 What does the negative sign in the law imply? (2)

10.4 A coil has 150 turns, each of area $4{,}8 \times 10^{-5}$ m$^2$, and it is made from insulated conducting wire. The wire is placed in a uniform magnetic field of $6 \times 10^{-5}$ T is such a way that the normal of the plane of the coil forms an angle of 15° to the magnetic field.

10.4.1 Calculate the magnetic field linkage for each turn. (3)

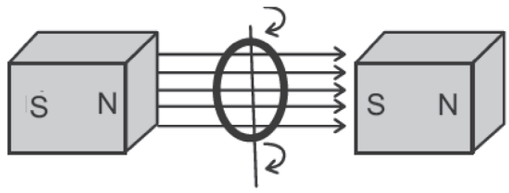
10.4.2 The coil rotates in 0,05 s to form a 75° angle between the normal of the plane of the coil and the magnetic field. Calculate the induced emf. (3)

10.4.3 Calculate the current induced in the coil if the resistance of the coil's circuit is 4 Ω. (2)

[14]

ASSESSMENTS

11. A coil with 250 windings has a radius of 0,05 m. It is rotated around an axle inside a uniform magnetic field of strength 2,5 T, as shown below.




11.1 Calculate the area of the coil. (Use $A = \pi r^2$) (2)

11.2 Calculate the magnetic flux through each turn of the coil, which is at 90° to the magnetic field, as indicated. (3)

11.3 The coil rotates through 45° and an emf of 2,5 V is induced. Calculate the time that the rotation took. (4)

11.4 Name the law that governs the induction of a current. (1)

11.5 State the law named above in 11.4. (2)

[12]

12. A coil with 100 windings (turns) is placed in a uniform magnetic field. The coil rotates clockwise through 90° (from the plane of the coil being perpendicular to the magnetic field, to the plane of the coil being parallel to the magnetic field) in 0,5 s and an induced emf of 1,5 V is created.

12.1 Calculate the change in magnetic flux linkage in this situation. (3)

12.2 Calculate the area of the coil. (3)

12.3 State 3 ways in which the induced emf could be increased. (3)

12.4 The effective resistance of the coil is 3 Ω. What is the induced current? (2)

12.5 What would be the effect of rotating the coil anti-clockwise instead of clockwise? (2)

[13]

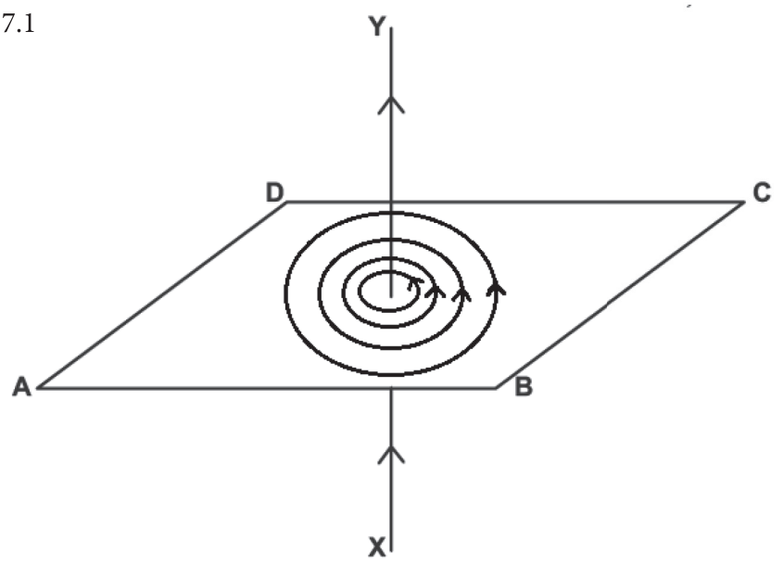
# MARKING GUIDELINES

## MULTIPLE CHOICE

1. D ✓✓ The electromagnets from their N poles on their left sides. [CL2] (2)
2. C ✓✓ Opposite direction, greater induction. [CL2] (2)
3. C ✓✓ The movement has to be at 90°. [CL2] (2)
4. D ✓✓ $\Phi = BA\cos\theta$ [CL2] (2)
5. B ✓✓ $\Phi = BA\cos\theta$ [CL3] (2)
6. A ✓✓ $\varepsilon = \frac{-N\Delta\Phi}{\Delta t}$ [CL3] (2)

## LONG QUESTIONS

7. 7.1




✓ 4 flux lines ✓circles ✓ arrows correct [CL2] (3)

7.2 The right hand rule – current goes in direction of right thumb ✓, fingers curl in direction of magnetic field ✓ (or equivalent) [CL3] (2)

7.3.1 90° ✓ [CL1] (2)

7.3.2 The electric field creates the current ✓✓ /causes charges to flow [CL4] (2)

7.3.3 Make an electromagnet etc. [CL2] (2)

8 8.1 The induced emf is equal to the rate of change ✓ of the magnetic flux ✓ [CL1] (2)

8.2 $\varepsilon = -N\frac{\Delta\Phi}{\Delta t}$ ✓✓ [CL1] (2)

8.3 Y to X ✓✓ [CL2] (2)

8.4 the negative sign ('-') ✓ This is because the induced emf opposes ✓ the change in flux. ✓ [CL3] (3)

8.5 One of: move the magnet more quickly, use a stronger magnetic field, use more turns. [CL2] (1)

9. 9.1 The induced emf is equal to the rate of change ✓ of the magnetic flux. ✓ [CL1] (2)
   9.2 B to A ✓ [CL2] (1)
   9.3 Galvanometer needle moves to opposite side ✓ then returns to centre zero ✓ when magnet stops moving. ✓ [CL3] (3)
   9.4 Bigger deflection of galvanometer needle. ✓ [CL2] (1)
   9.5 Bigger ✓ (double ✓) deflection of galvanometer needle again. [CL2] (2)
   9.6 Move the magnet in and out of the solenoid. ✓✓ [CL4] (2)

10. 10.1 The induced emf is equal to the rate of change ✓ of the magnetic flux. ✓ [CL1] (2)
   10.2 $\varepsilon = -N\frac{\Delta\Phi}{\Delta t}$ ✓✓ [CL1] (2)
   10.3 The negative sign implies that the induced emf opposes ✓ the change in flux. ✓ [CL3] (2)
   10.4.1 $\Phi = BA\cos\theta = 6\times10^{-5}$ ✓$\times 4,8\times10^{-5}\cos 15$ ✓$= 2,78\times10^{-9}$ Wb ✓ [CL2] (3)
   10.4.2 $\varepsilon = -N\frac{\Delta\Phi}{\Delta t}$
   $= -150\times\frac{6\times10^{-5}\times4,8\times10^{-5}\cos 75\checkmark - 2,78\times10^{-9}}{0,05\checkmark}$
   $= 6,1\times10^{-6}$ V ✓ [CL3] (3)
   10.4.3 $I = \frac{V}{R} = \frac{6,1\times10^{-6}}{4}\checkmark = 1,5\times10^{-6}$ A ✓ [CL2] (2)

11. 11.1 $A = \pi r^2 = 0,078\text{ m}^3 = 7,85\times10^{-3}\text{ m}^2$ [CL2] (2)
   11.2 $\Phi = BA\cos\theta = 2,5\checkmark\times 7,85\cos 0°\checkmark = 0,196$ Wb ✓ [CL2] (3)
   11.3 $\varepsilon = -N\frac{\Delta\Phi}{\Delta t} = -250\times\frac{2,5\times7,85\times10^{-3}\cos 45° - 0,0196}{\Delta t}$
   $2,5\checkmark = \frac{-250\times-0,00572}{\Delta t}\checkmark$
   $\Delta t = \frac{1,43}{2,5} = 0,057$ s ✓ [CL4] (4)
   11.4 Faraday's law of electromagnetic induction ✓ [CL1] (1)
   11.5 The induced emf is equal to the rate of change ✓ of the magnetic flux. ✓ [CL1] (2)

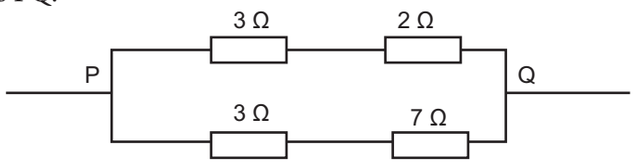
12. 12.1 $\varepsilon = -N\frac{\Delta\Phi}{\Delta t}$
   $1,5\checkmark = -100\checkmark\frac{\Delta\Phi}{0,5}$
   $\Delta\Phi = 7,5\times10^{-3}$ Wb ✓ [CL4] (3)
   12.2 $\Delta\Phi = BA(\cos 90 - \cos 0)$ ✓
   $7,5\times10^{-3} = 1,5A(-1)$ ✓
   $A = 0,005\text{ m}^2$ ✓ [CL3] (3)
   12.3 Increase the area of each turn ✓; the number of turns ✓; the magnetic field density/strength ✓; and reduce the time for rotations (ANY 3). [CL1] (3)
   12.4 $I = \frac{V}{R} = \frac{1,5}{3} = 2$ A ✓ [CL2] (2)
   12.5 It would reverse the direction ✓✓ of the induced current/emf. [CL3] (2)

# Topic 11: Electric Circuits

## QUESTIONS

### MULTIPLE CHOICE

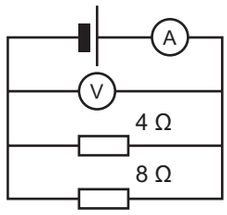
1. In the section of a circuit represented below, a potential difference of V volts is applied across PQ.




Which of the following gives the current in the 7 Ω resistor?

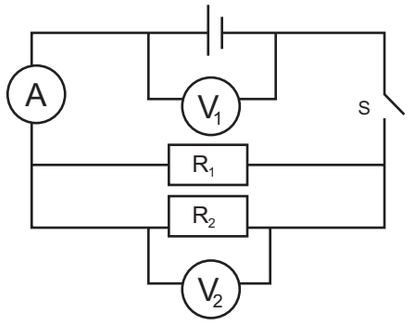
A V / 3 B V / 5
C V / 10 D V / 7 (2)

2. In the given circuit the cell has negligible resistance and the reading on the ammeter is **3 A**. What is the reading on the voltmeter?




A 3 V B 8 V
C 12 V D 11 V (2)

3. Consider the circuit shown below.




**R₁** and **R₂** are resistors with the same resistance. Switch **S** is **closed** and readings on voltmeters **V₁**, **V₂** and ammeter **A** are taken. The switch **S** is now opened and readings on all the meters are taken again.

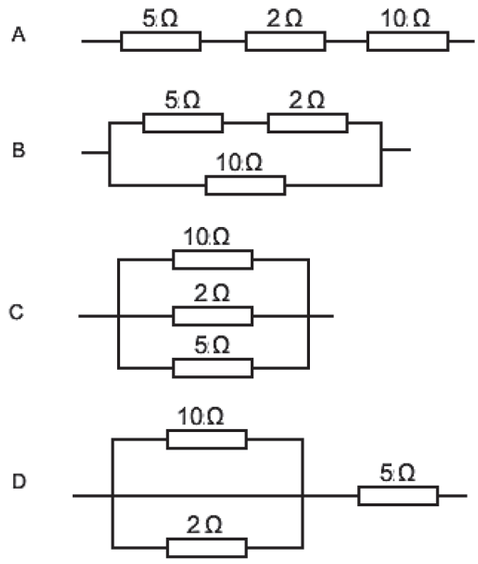
How do these new readings compare to the first set of readings?

| | Reading on $V_1$ | Reading on $V_2$ | Reading on A |
|---|---|---|---|
| A | Decreased | Increased | Zero |
| B | Increased | Zero | The same |
| C | The same | Zero | Zero |
| D | The same | The same | The same |

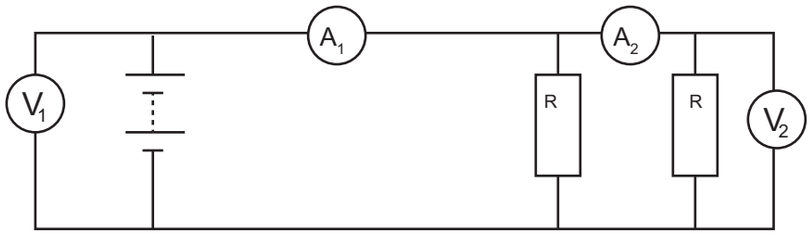
(2)

ASSESSMENTS

4. You are given four resistors, 10 Ω, 5 Ω and 2 Ω. You are told to combine them in such a way as to give the combination an overall resistance of approximately 4,1 Ω. The correct combination is… (2)



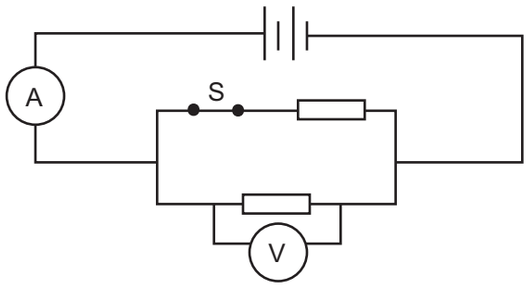

5. In the circuit below, $A_1$ and $A_2$ are ammeters with a very low resistance, and $V_1$ and $V_2$ are voltmeters with a very high resistance. The internal resistance of the battery is negligible. Both resistors R have the same resistance.




How do the readings on the ammeters and voltmeters compare? (2)

| | Readings on ammeters | Readings on voltmeters |
|---|---|---|
| A | $A_1 > A_2$ | $V_1 > V_2$ |
| B | $A_1 > A_2$ | $V_1 = V_2$ |
| C | $A_1 = A_2$ | $V_1 = V_2$ |
| D | $A_1 = A_2$ | $V_1 > V_2$ |

6. Consider the circuit shown in the diagram below. The battery has negligible internal resistance, and switch S is closed.




How will the readings on the ammeter and voltmeter change when switch S is opened?

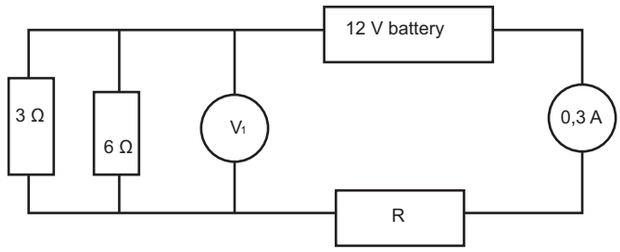
| | Ammeter reading | Voltmeter reading |
|---|---|---|
| A | Increase | Increase |
| B | Increase | No change |
| C | Decrease | Decrease |
| D | Decrease | No change |

(2)



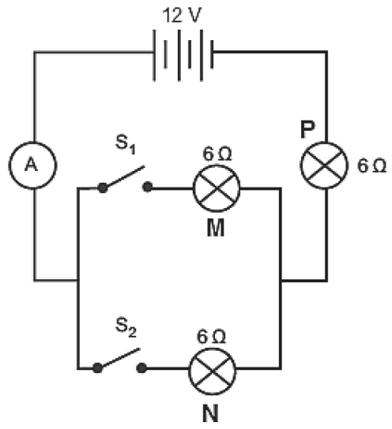
## LONG QUESTIONS

7. The circuit on the left shows a 3 Ω and 6 Ω resistor in parallel with each other and in series with an unknown resistor. The battery has an emf of 12 V and the reading on the ammeter is 0,3 A.




7.1 Determine the effective resistance of the parallel combination. (3)
7.2 Determine the reading on $V_1$. (3)
7.3 How much work is done by the battery in 2 minutes? (3)
7.4 Describe the transfer of energy in the battery. (2)
7.5 How much current flows through the 3 Ω resistor? (2)
7.6 Determine the value of R. (4)
[17]

8. In the circuit diagram below, three identical bulbs are connected as shown. The ammeter, connecting wires and 12 V battery have negligible resistance. Study the diagram and then answer the questions that follow.




**Both switches are now <u>closed.</u>**

8.1 What is the effective resistance of the circuit? (3)

8.2 Calculate the reading on the ammeter. (3)

8.3 Determine the potential difference across ...

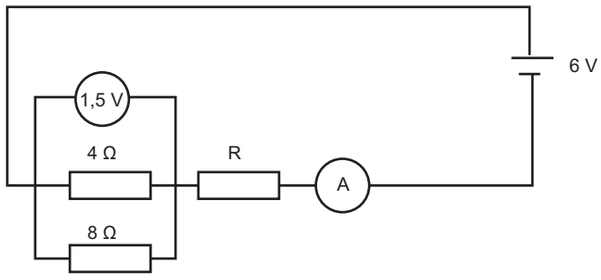
8.3.1 Bulb P. (2)

8.3.2 Bulb N. (2)

8.4 How would the ammeter reading change if switch $S_1$ is opened? Write increase, decrease or unchanged. Explain your answer. (2)

[12]

9. Consider the circuit diagram below. The battery has an emf of 6 V. The voltmeter across the parallel resistors reads 1,5 V. An unknown resistor, R is connected in series with the parallel resistors. Assume no internal resistance in the battery.




9.1 Calculate the effective resistance of the parallel combination of resistors. (3)

9.2 Calculate the reading on the ammeter. (3)

9.3 Calculate the potential difference across resistor, R. (2)

9.4 What is the resistance of R? (2)

9.5 Calculate the work done in the 8 Ω resistor in 3 minutes. (3)

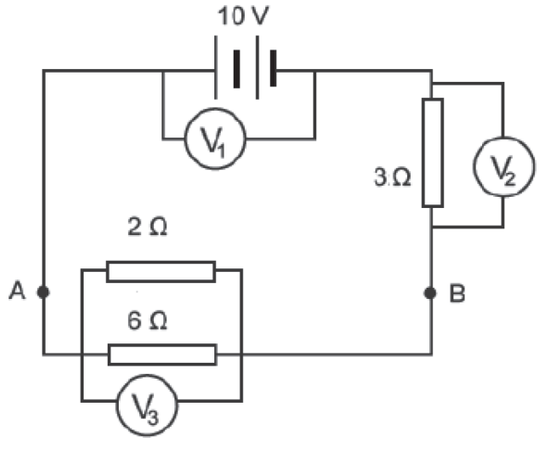
[13]

10. Two learners decide to investigate the relationship between the length of a piece of nichrome wire and the total resistance of the wire. They decide to use an ammeter, voltmeter, 3 cell battery and switch to perform the experiment with different lengths of wire. They also decide to keep the temperature, thickness and type of wire constant throughout the experiment.
They drew up and completed the following table of results:

| Length of wire (cm) | Potential difference (V) | Current (A) | Resistance (Ω) |
|---|---|---|---|
| 10 | 30 | 1,67 | 18 |
| 20 | 60 | 1,62 | 37 |
| 30 | 89 | 1,68 | 53 |
| 40 | 120 | **X** | 72 |
| 50 | 151 | 1,68 | 90 |

10.1 Give a hypothesis for this experiment. (3)
10.2 Draw a circuit diagram that could be used for this experiment. (4)
10.3 Identify the dependent variable. (2)
10.4 Identify the independent variable. (1)
10.5 Determine the missing current reading, **X** to two decimal places. (2)
10.6 Draw a graph of these results on graph paper. Label the axes and choose a suitable scale, provide a descriptive heading and draw a line of best fit. (5)
[17]

11. The battery shown in the circuit below has an emf of 10 V and no internal resistance.




11.1 Calculate the total resistance in the external circuit. (3)
11.2 Calculate the current in the 6 Ω resistor. (4)
11.3 Calculate reading on voltmeter $V_2$. (3)
11.4 Calculate the energy dissipated in the 6 Ω resistor in 2 minutes. (3)

11.5 Calculate the power dissipated in the battery. (3)

11.6 Points A and B in the circuit are now joined by a connecting lead of very low resistance. How will this affect ...

11.6.1 the reading on voltmeter $V_1$? Explain your answer. (3)

11.6.2 the current in each of the resistors connected in parallel? Explain your answer. (2)

[21]

# MARKING GUIDELINES

## MULTIPLE CHOICE

1 A✓✓ Current splits 2:1 [CL2] (2)

2 A✓✓ $V = RI = (8/3)(3)$ V [CL3] (2)

3 C✓✓ With **s** open, $V_1$ reads the emf, and no current passes through the circuit, so the ammeter reads 0 A and $V_2$ reads 0 V. [CL4] (2)

4 B✓✓ $R_{//} = (7 \times 10)/(7 + 10) = 4{,}1\ \Omega$ [CL3] (2)

5 B✓✓ Current splits in parallel [CL3] (2)

6 D✓✓ Opening the switch S, converts it from a parallel into a series circuit [CL2] (2)

## LONG QUESTIONS

7. 7.1 $\frac{1}{R_{parallel}} = \frac{1}{R_1} + \frac{1}{R_2}$

$= \frac{1}{3} + \frac{1}{6}\checkmark = \frac{3}{6} = \frac{1}{2}\checkmark$

$\therefore R_{parallel} = 2\ \Omega\checkmark$ [CL2] (3)

7.2 $V_1 = V_{parallel} = R_{parallel}\ I_{parallel} = 2\checkmark \times 0{,}3\checkmark = 0{,}6$ V ✓ [CL2] (3)

7.3 $W = VIt = (12)(0{,}3)\checkmark(120)\checkmark = 432$ J ✓ [CL3] (3)

7.4 The battery converts chemical energy ✓ to electrical energy. ✓ [CL2] (2)

7.5 $I_3 = \frac{V_3}{R_3} = \frac{0{,}6}{3}\checkmark = 0{,}2$ A ✓ [CL2] (2)

7.6 $V_R = 12 - 0{,}6 = 11{,}4$ V ✓

$R = \frac{V}{I} = \frac{11{,}4\checkmark}{0{,}3\checkmark} = 38\ \Omega\checkmark$ [CL2](4)

8. 8.1 $\frac{1}{R_{parallel}} = \frac{1}{R_1} + \frac{1}{R_2}$

$\frac{1}{R_{parallel}} = \frac{1}{6} + \frac{1}{6} = \frac{2}{6}\checkmark$ OR $R_{parallel} = \frac{product}{sum} = 3\ \Omega$

$R_{parallel} = \frac{6}{2} = 3\ \Omega\checkmark$

$R_{Total} = 3\ \Omega + 6\ \Omega = 9\ \Omega\checkmark$ [CL2] (3)

8.2 $I = \frac{V}{R}\checkmark = \frac{12}{9}\checkmark = 1{,}33$ A ✓ [CL2] (3)

8.3.1 $V_P = I_P R_P = (1{,}33)(6)\checkmark = 7{,}98$ V ✓ (allow coe) [CL2] (2)

8.3.2 $V_P = V_P = 12 - 7{,}98\checkmark = 4{,}02$ V ✓ (allow coe) [CL3] (2)

8.4 Current will decrease ✓; more resistors in series; resistance increased ✓ [CL3] (2)

9. 9.1 $\frac{1}{R_{parallel}} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{8} + \frac{1}{4}\checkmark = \frac{1+2}{8} = \frac{3}{8}\checkmark$

$R_{parallel} = \frac{8}{3} = 2,6\ \Omega\checkmark$ [CL2] (3)

9.2 $I = \frac{V}{R}\checkmark = \frac{1,5}{2,6}\checkmark = 0,56\ \text{A}\checkmark$ (Allow c.o.e.)

OR

$I = I_{4\Omega} + I_{6\Omega} = \frac{1,5}{8}\checkmark + \frac{1,5}{4}\checkmark = 0,56\ \text{A}\checkmark$ [CL2] (3)

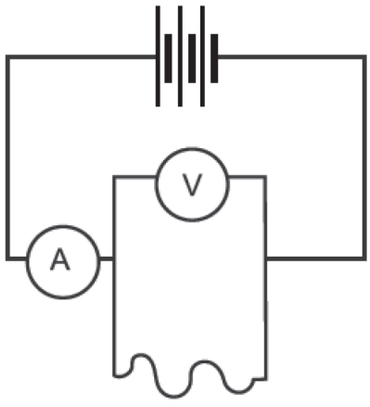
9.3 $V_R = V_T - V_{parallel} = 6 - 1,5\checkmark = 4,5\ \text{V}\checkmark$ [CL2] (2)

9.4 $R_R = \frac{V}{I} = \frac{4,5}{0,5625}\checkmark = 8\ \Omega\checkmark$ (Allow c.o.e.) [CL2] (2)

9.5 $P = \frac{V^2}{R}t = \frac{1,5^2}{8}\checkmark 180\checkmark = 50,6\ \text{W}\checkmark$ (Allow c.o.e.) [CL3] (3)

10. 10.1 The resistance is (directly) proportional to the length.
(✓ for each variable, ✓ for a relationship) [CL2] (3)

10.2 [CL3] (4)




✓ for A in series

✓ for V in parallel with wire

✓ ✓ rest of circuit

Can use a resistor symbol for the wire

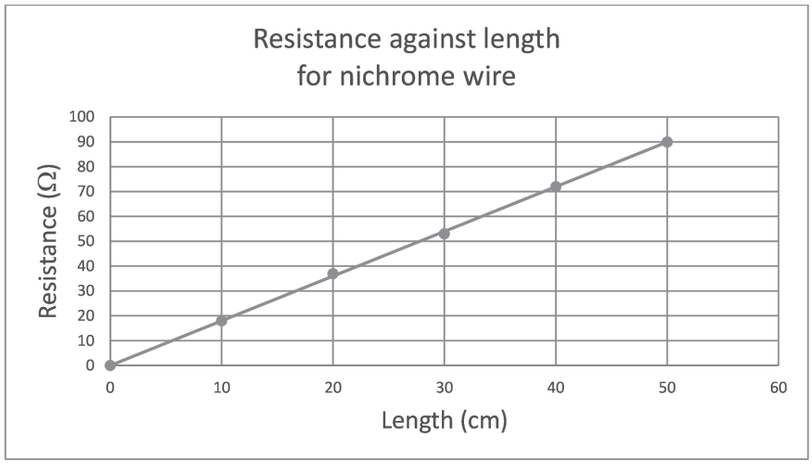
Nichrome wire of varying lengths

10.3 Resistance ✓✓ [CL3] (2)

10.4 Wire length ✓ [CL2] (1)

10.5 $I = \frac{V}{R} = \frac{120}{72}\checkmark = 1,67\ \text{A}\checkmark$ [CL2] (2)

10.6




Heading ✓; axes well scaled, with labels and units ✓; points plotted ✓✓; line of best fit ✓ [CL2] (5)

11. 11.1 $\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{2} + \frac{1}{6} = \frac{4}{6}$✓

$R_P = \frac{6}{4} = 1,5\ \Omega$✓

$R_T = 1,5 + 3 = 4,5\ \Omega$✓ [CL2] (3)

11.2 $I_{tot} = \frac{V}{R_T} = \frac{10}{4,5} = 2,22$ A✓ (c.o.e.)

$V_P = I_{tot} \times R_P = 2,22 \times 1,5$✓$= 3,33$ V✓

$I_{6\Omega} = \frac{V_P}{R} = \frac{3,33}{6} = 0,56$ A✓ [CL3] (4)

11.3 $V_2 = IR = 2,22$✓$\times\ 3$✓ $= 6,66$ V✓ (c.o.e.) [CL3] (3)

11.4 $E = I^2Rt = (0,56)^2 \times 6$✓$\times 120$✓$= 225,79$ J✓ (c.o.e.)

Other equations could be used. [CL3] (3)

11.5 $P = VI = 10$✓$\times\ 2,22 = 22,2$ W✓ (c.o.e.) [CL2] (3)

11.5.1 $V_1$ will not change. ✓

The resistance of the circuit decreases to 3 Ω ✓, but the current will increase, ✓ so V remains 10 V. [CL4] (3)

11.5.2 No current passes through the parallel resistors ✓

OR The battery has an emf of 10 V and no internal resistance. ✓

as all the current will flow through the low resistance wire. ✓ [CL4] (2)

ASSESSMENTS

# Topic 12: Energy and Chemical Change

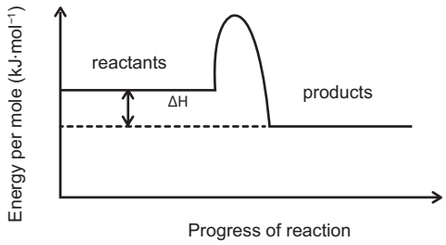
## QUESTIONS

### MULTIPLE CHOICE QUESTIONS

1. Which ONE of the following statements CORRECTLY describes the characteristics of an endothermic reaction?
   A ΔH is positive and the products have less potential energy than the reactants.
   B ΔH is positive and the products have more potential energy than the reactants.
   C ΔH is negative and the products have less potential energy than the reactants.
   D ΔH is negative and the products have more potential energy than the reactants. (2)

2. Which ONE of the following statements is CORRECT for an endothermic reaction?
   A The temperature of the surroundings increases.
   B The enthalpy change for the reaction is negative.
   C Heat flows from the surroundings into the system.
   D The enthalpy of products is less than the enthalpy of reactants. (2)

3. Consider the following graph which represents the change in energy during a chemical reaction.




   ΔH in this reaction is …
   A negative, since energy is gained.
   B positive, since energy is gained.
   C positive, since energy is lost.
   D negative, since energy is lost. (2)

4. Consider the reaction represented by the equation below:

   $2Fe(s) + 3CO_2(g) \rightarrow Fe_2O_3(s) + 2CO(g)$ $\Delta H = +53{,}2$ kJ

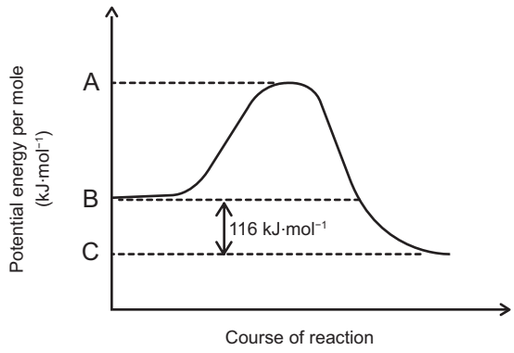
   Which ONE of the following statements is TRUE?
   For each mole of Fe that reacts, …
   A 26,6 kJ of energy are released.
   B 26,6 kJ of energy are absorbed.
   C 53,2 kJ of energy are released.
   D 53,2 kJ of energy are absorbed. (2)

## LONG QUESTIONS

5. A barium hydroxide solution, $Ba(OH)_2(aq)$, reacts with a nitric acid solution, $HNO_3(aq)$, according to the following balanced equation:

$$Ba(OH)_2(aq) + 2HNO_3(aq) \rightarrow Ba(NO_3)_2(aq) + 2H_2O(\ell)$$

The potential energy per mole graph below shows the change in potential energy for this reaction.




5.1 Is this reaction ENDOTHERMIC or EXOTHERMIC? Give a reason for your answer. (2)

5.2 Use energy values A, B and C indicated on the graph and write down an expression for each of the following:

5.2.1 The energy of the activated complex (1)

5.2.2 The activation energy for the forward reaction (1)

5.2.3 ΔH for the reverse reaction (1)

5.3 Calculate the amount of energy released during the reaction if 0,18 moles of $Ba(OH)_2(aq)$ reacts completely with the acid. (3)

[8]

6. Hydrogen gas and oxygen gas react to form water according to the following balanced equation:

$$2H_2(g) + O_2(g) \rightarrow 2H_2O(g) + 241{,}8\ kJ{\cdot}mol^{-1}$$

The activation energy ($E_A$) for this reaction is 1 370 $kJ{\cdot}mol^{-1}$.

6.1 Define the term "activation energy". (2)

6.2 Sketch a potential energy per mole versus reaction coordinate graph for the above reaction. Clearly label the axes and indicate the following on the graph:

- ΔH
- $E_A$ for the forward reaction
- Energy of reactants and products
- Activated complex (6)

6.3 Write down the value of the:

6.3.1 Heat of reaction (1)

6.3.2 Activation energy for the following reaction:

$$2H_2O(g) \rightarrow 2H_2(g) + O_2(g)$$ (2)

[11]

ASSESSMENTS

7. Consider the reaction represented by the equation below.

$$CO_2(g) + 2H_2O(\ell) \rightarrow CH_4(g) + 2O_2(g)$$

During the reaction the temperature of the reaction mixture decreases.

7.1 Define the term "heat of reaction". (2)

7.2 Does the heat of reaction (ΔH) for this reaction have a positive or negative value? Explain the answer by referring to the energy changes involved. (3)

7.3 Sketch a labelled potential energy per mole graph for this reaction. On the graph, show the position of the reactants, products, ΔH and activation energy. (6)

[11]

8. When sodium hydroxide (NaOH) pellets dissolve in water, the reaction is exothermic, while the dissolution of ammonium nitrate ($NH_4NO_3$) is endothermic.

Compare these two reactions in terms of ...

8.1 heat exchange with the surroundings. (2)

8.2 energy of the reactants and the products. (2)

8.3 the sign of the enthalpy change. (2)

[6]

9. Classify the following reactions as exothermic or endothermic:

9.1 The reaction between hydrogen and oxygen. (1)

9.2 $C(g) + H_2O(g) + \text{energy} \rightarrow CO(g) + H_2(g)$ (1)

9.3 $2KNO_3 \rightarrow 2KNO_2 + O_2 \qquad \Delta H > 0$ (1)

9.4 $NaOH(s) \rightarrow Na+(aq) + OH^-(aq) \qquad \Delta H < 0$ (1)

9.5 $H_2 + I_2 \rightarrow 2HI \qquad \Delta H = -21\ kJ{\cdot}mol^{-1}$ (1)

[5]

# MARKING GUIDELINES

## MULTIPLE CHOICE

1. B ✓✓ All endothermic reactions emit less energy on bond formation compared to the amount of energy absorbed from the environment to get the reaction started. This leaves a positive ΔH value as well as leaving the energy of the products greater than the initial energy of the reactants. [CL2] (2)

2. C ✓✓ Endothermic reactions absorb energy (heat) from their surroundings. [CL2] (2)

3. D ✓✓ Here it can be seen that the energy of the products is lower than the energy of the reactants. This means that more energy is released on bond formation that was initially absorbed to get the reaction started (activation energy). Therefore there is excess energy in the system, thus ΔH will be negative and this energy is transferred out of the system in the form of heat/light/sound. [CL2] (2)

4. B ✓✓ It is a endothermic reaction as ΔH is positive. As there are 2 moles of Fe reacting, then each mole must absorb 26,2 kJ of energy. [CL2] (2)

## LONG QUESTIONS

5. 5.1 Exothermic ✓ Energy of products lower than energy of reactants ✓ [CL2] (2)

   5.2.1 A ✓✓ [CL2] (1)

   5.2.2 A – B ✓✓ [CL2] (1)

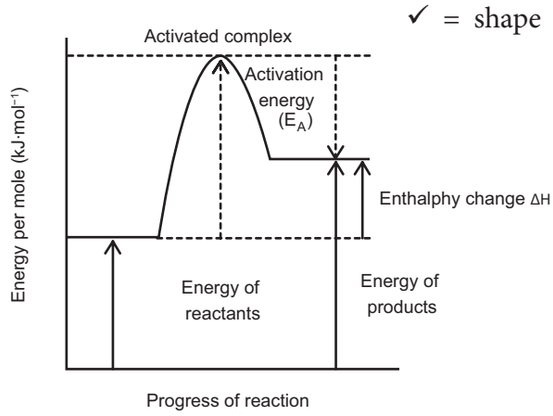
   5.2.3 B – C ✓✓ [CL3] (1)

   5.3 If 1 mol releases 116 kJ amount of energy
   Then 0,18 mol of $Ba(OH)_2$ will release $= 0,18 \times 116$ ✓✓
   $= 20,88$ kJ ✓ [CL2] (3)

ASSESSMENTS

6. 6.1 This is the minimum energy required to start a chemical reaction.✓✓ [CL2] (2)

6.2 ✓ = shape




[CL2] (6)

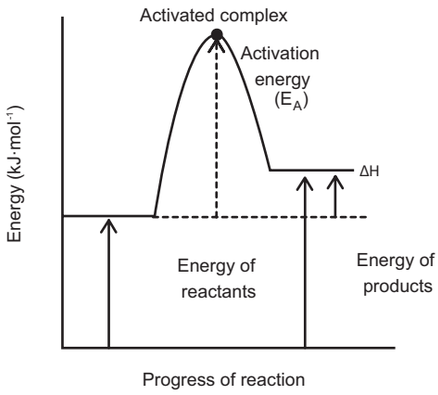
7.3.1 $-241{,}8\ kJ{\cdot}mol^{-1}$ ✓ [CL2] (1)

7.3.2 1 370 – 241,8 ✓= $+1\ 128{,}2\ kJ{\cdot}mol^{-1}$ ✓ [CL2] (2)

7. 7.1 The measure of the amount of heat energy transferred during a chemical reaction. ✓✓ [CL1] (2)

7.2 Positive. ✓ The decrease in temperature indicates that energy was absorbed from the environment,✓ hence it must be an endothermic reaction ✓ where ΔH is positive. [CL2] (3)

7.3




✓ = shape ✓ = labels

[CL2] (6)

8. 8.1 NaOH(aq): gives out heat to surroundings and feels warm ✓

$NH_4NO_3$(aq): gains heat from surroundings and feels cool ✓ [CL2] (2)

8.2 NaOH(aq): Products have less energy than reactants ✓

$NH_4NO_3$(aq): Products have more energy than reactants ✓ [CL2] (2)

8.3 NaOH(aq): ΔH negative ✓

$NH_4NO_3$(aq): ΔH positive ✓ [CL2] (2)

9. 9.1 Exothermic ✓ [CL1] (1)

9.2 Endothermic ✓ [CL1] (1)

9.3 Endothermic ✓ [CL1] (1)

9.4 Exothermic ✓ [CL1] (1)

9.5 Exothermic ✓ [CL1] (1)

# Topic 13: Types of Reactions

## QUESTIONS

### PART I: ACIDS AND BASES

### MULTIPLE CHOICE QUESTIONS

1. Consider the following acid-base reactions:

$$NH_3(g) + H_2O(l) \rightarrow NH_4^+(aq) + OH^-(aq)$$
$$SO_4^{2-}(aq) + HNO_3(aq) \rightarrow HSO_4^-(aq) + NO_3^-(aq)$$

The substances acting as proton acceptors in the above reactions are:

A $H_2O$ and $SO_4^{2-}$
B $NH_3$ and $SO_4^{2-}$
C $NH_3$ and $HNO_3$
D $H_2O$ and $HNO_3$ (2)

2. Consider the following reversible reaction:

$$H_3O^+ + OH^- \rightleftharpoons H_2O + H_2O$$

The substance which is acting as an ampholyte is …

A $H_3O^+$ ions.
B $OH^-$ ions.
C $H_2O$ molecules.
D None of the above. (2)

3. Consider the reaction represented by the equation shown below.

$$HC\ell O_2 + H_2O \rightarrow H_3O^+ + C\ell O_2^-$$

Which **ONE** of the following is a conjugate acid-base pair in the above reaction?

A $HC\ell O_2$ and $C\ell O_2^-$
B $HC\ell O_2$ and $H_2O$
C $C\ell O_2^-$ and $H_3O^+$
D $HC\ell O_2$ and $H_3O^+$ (2)

4. A Brønsted acid is a(n) ...

A electron donor.
B proton acceptor.
C electron acceptor.
D proton donor. (2)

5. Consider the following chemical reaction represented by the equation shown below:

$$HCO_3^- + HC_2O_4^- \rightleftharpoons H_2CO_3 + C_2O_4^{2-}$$

Which ONE of the following CORRECTLY identifies the order of Lowry-Brønsted acids and bases in the above reaction?

A Base, acid, acid, base
B Acid, base, base, acid
C Acid, base, acid, base
D Base, acid, base, acid (2)

## LONG QUESTIONS

6. When sulfuric acid reacts with water, it ionises in two steps, as shown in the two balanced equations below.

I: $H_2SO_4(aq) + H_2O(\ell) \rightarrow H_3O^+(aq) +$ __1__(aq)
II: __1__(aq) + $H_2O(\ell) \rightarrow H_3O^+(aq) +$ __2__(aq)

6.1 Define an acid in terms of the Lowry-Brønsted theory. (1)
6.2 Write down the FORMULA of:
6.2.1 The conjugate base __1__(aq) in reaction I. (1)
6.2.2 The conjugate acid in reaction II. (1)
6.2.3 __2__(aq). (1)
6.2.4 A substance that acts as an ampholyte in these reactions. (1)
6.3 A few drops of bromothymol blue indicator are added to potassium hydroxide solution in a beaker. A dilute sulfuric acid solution is now gradually added to this solution until the colour of the indicator changes. Write down the:
6.3.1 type of reaction that takes place. (Write down only REDOX, PRECIPITATION or NEUTRALISATION.) (1)
6.3.2 balanced equation for the reaction that takes place. (3)
61.3.3 colour change of the indicator. (2)
6.3.4 NAME of the salt formed in this reaction. (1)
[12]

7. Acids and bases can be defined in terms of the following two theories:
   I: Arrhenius theory
   II: Lowry-Brønsted theory

   7.1 According to the Arrhenius theory, sodium hydroxide is classified as a base. Write down the chemical formula of the ion responsible for the basic properties of sodium hydroxide. (1)

   7.2 Consider the reaction represented by the incomplete equation below:

   $$HNO_3(aq) + OH^-(aq) \rightleftharpoons \_\_\_\_\_ + \_\_\_\_\_$$

   7.2.1 Use your knowledge of the Lowry-Brønsted theory to write a balanced equation for this reaction. (2)

   7.2.2 Write down the formulae of ONE conjugate acid-base pair in this reaction. (2)

   [5]

8. 8.1 Limestone, or sometimes ash, is used in pit latrines (long drops) to neutralise acidic waste. Limestone reacts with hydrochloric acid according to the following UNBALANCED equation:

   $$CaCO_3(s) + HC\ell(aq) \rightarrow CaC\ell_2(aq) + H_2O(\ell) + \_\_\_\_\_(g)$$

   8.1.1 Define "an acid" in terms of the Arrhenius theory. (1)

   8.1.2 Is ash acidic or basic? Explain your answer. (2)

   8.1.3 What is the unknown product in the reaction above? (1)

   8.1.4 Rewrite the above equation into your ANSWER BOOK and then balance the equation. (1)

   8.2 Sulfuric acid reacts with water in two steps as represented by the equations below.

   Equation I: $H_2SO_4(aq) + H_2O(\ell) \rightleftharpoons H_3O^+(aq) + HSO_4^{2-}(aq)$
   Equation II: $HSO_4^-(aq) + H_2O(\ell) \rightleftharpoons H_3O^+(aq) + SO_4^{2-}(aq)$

   8.2.1 Define the term "ampholyte". (2)

   8.2.2 Write down the FORMULA of a species that acts as an ampholyte in the above reactions. (1)

   8.2.3 Write down the NAME of the conjugate base of the hydrogen sulfate ion. (1)

   [9]

ASSESSMENTS

## PART II: REDOX REACTIONS

### MULTIPLE CHOICE QUESTIONS

1. In the chemical equation: $H_2(g) + C\ell_2(g) \rightarrow 2HC\ell(g)$, $H_2$ is the ...
   A oxidising agent because it is oxidised.
   B oxidising agent because it is reduced.
   C reducing agent because it is oxidised.
   D reducing agent because it is reduced. (2)

2. Which ONE of the following balanced equations represents a redox reaction?
   A $H^+(aq) + OH^-(aq) \rightarrow H_2O(\ell)$
   B $Mg(s) + CuSO_4(aq) \rightarrow Cu(s) + MgSO_4(aq)$
   C $2NaC\ell(aq) + Pb(NO_3)_2(aq) \rightarrow 2NaNO_3(aq) + PbC\ell_2(s)$
   D $H_2SO_4(aq) + Ba(NO_3)_2(aq) \rightarrow BaSO_4(s) + 2HNO_3(aq)$ (2)

3. During the extraction of gold, zinc powder is added to a solution of gold cyanide to produce gold according to the following balanced equation:

   $$Zn(s) + 2NaAu(CN)_2(aq) \rightarrow 2Au(s) + Zn(CN)_2(aq) + 2NaCN(aq)$$

   The oxidising agent in this reaction is …
   A $Au^+$
   B Zn
   C $Na^+$
   D $CN^-$ (2)

4. Consider the reaction represented by the balanced ionic equation below.

   $$Cr_2O_7^{2-}(aq) + 14H^+(aq) + 3S^{2-}(aq) \rightarrow 2Cr^{3+}(aq) + 3S(s) + 7H_2O(\ell)$$

   When this reaction takes place, …
   A the oxidation number of sulfur does not change.
   B $S^{2-}$ is reduced by the $Cr_2O_7^{2-}(aq)$.
   C $H^+(aq)$ oxidises the $S^{2-}(aq)$.
   D $S^{2-}(aq)$ is oxidised by the $Cr_2O_7^{2-}(aq)$. (2)

5. The oxidation number of N in the formula $HNO_3$ is …
   A +3.
   B -5.
   C +5.
   D -7. (2)

## LONG QUESTIONS

6. 6.1 Oxidation numbers make it easier to determine whether an element or a substance is oxidised or reduced during a chemical reaction.
   - 6.1.1 Define the term "oxidation" with reference to oxidation numbers. (1)
   - 6.1.2 Calculate the oxidation number of chromium in $Cr_2O_7^{2-}$. (2)
   - 6.1.3 Calculate the oxidation number of oxygen in $H_2O_2$. (2)

   6.2 Consider the UNBALANCED equation shown below:

   $$Fe^{2+}(aq) + C\ell_2(g) \rightarrow Fe^{3+}(aq) + C\ell^-$$

   - 6.2.1 Define the term "reducing agent" with reference to electron transfer. (2)

   From the above equation, write down the ...
   - 6.2.2 FORMULA of the reducing agent. (2)
   - 6.2.3 FORMULA of the oxidising agent. (2)
   - 6.2.4 Reduction half-reaction. (2)
   - 6.2.5 Oxidation half-reaction. (2)
   - 6.2.6 Balanced net redox reaction. (2)

7. Redox reactions can be explained in terms of electron transfer as well as oxidation numbers. The unbalanced equations A, B and C below represent three redox reactions.

   A: $Zn(s) + HC\ell(aq) \rightarrow ZnC\ell_2(aq) + H_2(g)$

   B: $NiO(s) + CO(g) \rightarrow Ni(s) + CO_2(g)$

   C: $Cu(s) + HNO_3(aq) \rightarrow Cu(NO_3)_2(aq) + NO(g) + H_2O(\ell)$

   7.1 Define "reduction" in terms of electron transfer. (1)

   7.2 Write down the formula of the substance which is:
   - 7.2.1 oxidised in reaction A. (1)
   - 7.2.2 the reducing agent in reaction B. Explain the answer in terms of oxidation numbers. (3)

   7.3 For reaction C, write down the balanced equation using the ion-electron method. Show the oxidation and reduction half-reactions during balancing. (5)

8. A mixture containing a 100 g $A\ell$ and 200 g MnO was heated to initiate the following redox reaction:

   $$2\,A\ell + 3\underline{Mn}O \rightarrow \underline{A\ell_2}O_3 + 3Mn$$

   8.1 Define "oxidation". (1)

   8.2 Give the value of the oxidation numbers of the underlined elements. (2)

   8.3 Identify the oxidising agent in the above-mentioned reaction. Justify your answer by referring to oxidation numbers. (3)

   8.4 The above-mentioned reaction will proceed until the limiting reactant is completely consumed. Which reactant is the limiting reactant? Show your working. (5)

9. Consider the following reaction:

$$H^+ + Cu + NO_3^- \rightarrow H_2O + Cu^{2+} + NO$$

9.1 Use the ion-electron method to write half-reactions for oxidation and reduction.
9.1.1 the oxidation half-reaction. (2)
9.1.2 the reduction half-reaction. (2)
9.2 Write the balanced ionic equation for this reaction. (4)

# MARKING GUIDELINES

## ACIDS AND BASES

### MULTIPLE CHOICE

1. B ✓✓ Both these molecules will gain a H atom in the reaction; these are known as proton acceptors. [CL3] (2)
2. C ✓✓ In the back reaction, the $H_2O$ molecule will both gain and lose a $H^+$ ion, thus it acts as both an acid and a base, hence an ampholyte. [CL2] (2)
3. A ✓✓ These chemical species differ from each other by one H. $HClO_2$ loses $H^+$ and thus is acidic which makes $ClO_2^-$ the conjugate base. [CL3] (2)
4. D ✓✓ Straight definition of a Lowry-Brønsted acid from textbook. [CL1] (2)
5. A ✓✓ Being reversible, you must look at both forward and reverse reactions. Follow the exchange of $H^+$ in both directions. [CL3] (2)

### LONG QUESTIONS

6. 6.1 An acid is a proton donor. ✓ [CL1] (1)
   - 6.2 6.2.1 $HSO_4^-$ ✓ [CL2] (1)
   - 6.2.2 $H_3O^+$ ✓ [CL2] (1)
   - 6.2.3 $SO_4^{2-}$ ✓ [CL2] (1)
   - 6.2.4 $HSO_4^-$ ✓ [CL2] (1)
   - 6.3 6.3.1 Neutralisation ✓ [CL1] (1)
   - 6.3.2 $H_2SO_4$ ✓ + 2KOH → $K_2SO_4$ ✓ + $H_2O$ ✓ balancing [CL2] (3)
   - 6.3.3 Blue ✓ to green ✓ [CL2] (2)
   - 6.3.4 Potassium sulfate ✓ [CL2] (1)

7. 7.1 $OH^-$ ✓ [CL1] (1)
   - 7.2 7.2.1 $HNO_3$ + $OH^-$ → $NO_3^-$ ✓ + $H_2O$ ✓ [CL2] (2)
   - 7.2.2 $HNO_3$ ✓ and $NO_3^-$ ✓ OR $OH^-$ ✓ and $H_2O$ ✓ [CL2] (2)

8. 8.1 8.1.1 An acid is a substance that releases hydrogen ions ($H^+$ ions) in aqueous solution. ✓ [CL1] (1)
   - 8.2 8.1.2 Basic .✓ As the ash is said to neutralise ✓ the acid in the latrine, thus must be a base. [CL1] (2)
   - 8.1.3 $CO_2$ ✓ [CL1] (1)
   - 8.1.4 $CaCO_3$ + 2HCl ✓ → $CaCl_2$ + $H_2O$ + $CO_2$ [CL2] (1)
   - 8.3 8.2.1 This is a chemical substance that can act as both an acid and a base. ✓✓ [CL1] (2)
   - 8.2.2 $HSO_4^-$ ✓ [CL1] (1)
   - 8.2.3 Sulfate anion ✓ [CL2] (1)

## REDOX REACTIONS

## MULTIPLE CHOICE

1. C ✓✓ $H_2$ changes its oxidation number from 0 to +1, thus is being oxidised. Reducing agents undergo oxidation. [CL2] (2)

2. B ✓✓ The only reaction that has changes in oxidation numbers thus it must be a REDOX reaction. [CL2] (2)

3. A ✓✓ The oxidation number of Au in $NaAu(CN)_2$ is +1 and it changes to 0 for the element Au. Thus the oxidising agent is $Au^+$. [CL3] (2)

4. D ✓✓ $S^{2-}$ changes its oxidation number from -2 to 0 (S). It has been oxidised which means it must have lost two of its electrons to $Cr_2O_7^{2-}$. Thus $S^{2-}$ is oxidised by $Cr_2O_7^{2-}$. [CL3] (2)

5. C ✓✓ The oxidation number of N = +5. [CL2] (2)

## ANSWERS TO LONG QUESTIONS

6. 6.1 6.1.1 The oxidation number of a substance increases when it loses electrons therefore oxidation is the process whereby the oxidation number of a substance increases. ✓ [CL1] (1)

   6.1.2 +6 ✓✓ [CL2] (2)

   6.1.3 -1 ✓✓ [CL2] (2)

   6.2 6.2.1 Reducing agents assist the reduction process by themselves losing electrons ✓ and thereby undergoing oxidation. ✓ [CL2] (2)

   6.2.2 $Fe^{2+}$ ✓✓ [CL2] (2)

   6.2.3 $Cl_2$ ✓✓ [CL2] (2)

   6.2.4 $Cl_2 + 2e^- \rightarrow 2Cl^-$ ✓✓ [CL2] (2)

   6.2.5 $Fe^{2+} \rightarrow Fe^{3+} + e^-$ ✓✓ [CL2] (2)

   6.2.6 $2Fe^{2+} + Cl_2 \rightarrow 2Fe^{3+} + 2Cl^-$ ✓✓ [CL2] (2)

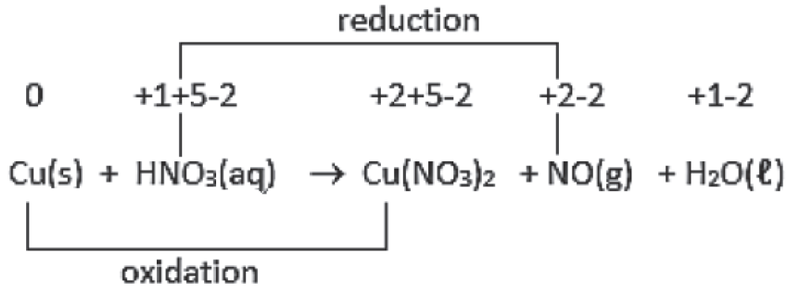
7. 7.1 Reduction is the process of electron gain in a REDOX reaction. [CL1] (1)

   7.2.1 Zn ✓ [CL2] (1)

   7.2.2 $\overset{+2}{CO}$ $\overset{+4}{CO_2}$ ✓

   C changes its oxidation number from +2 to +4, thus has been oxidised ✓ which makes CO the reducing agent. ✓ [CL2] (3)

7.3




Oxidation: $Cu \rightarrow Cu^{2+} + 2e^-$ (×3)
Reduction: $NO_3^- + 3e^- \rightarrow NO$ (×2)
Net reaction: $3Cu + 2NO_3^- \rightarrow 3Cu^{2+} + 2NO$ [CL3] (5)

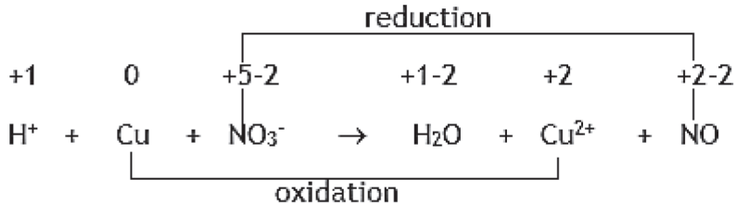
8. 8.1 The process where electrons are lost is a REDOX reaction. ✓ [CL1] (1)

8.2 Mn = +2 ✓ Al = +3 ✓ [CL2] (2)

8.3 $\overset{+2}{MnO}$ $\overset{0}{Mn}$ ✓
MnO is reduced to Mn, ✓ thus MnO is the oxidising agent. ✓ [CL2] (3)

8.4 Aℓ: $n = \frac{m}{M} = \frac{100}{27} = 3,70 \text{ mol}$✓
MnO: $n = \frac{m}{M} = \frac{200}{55+16} = 2,82 \text{ mol}$✓
Ratio of Aℓ : Mn = 2 : 3 ✓(from the balanced equation) = 1: 1,5
But this ratio gives Aℓ : Mn = 3,70 : 2,82 = 1 : 0,76 ✓ (or equivalent reasoning)
Therefore MnO is the limiting reagent.✓ [CL3] (5)

9. 9.1




Oxidation: $Cu \rightarrow Cu^{2+} + 2e^-$ (×3) ✓
Reduction: $NO_3^- + 3e^- \rightarrow NO$ (×2) ✓ [CL3] (4)

9.2 $2H^+ + 3Cu + 2NO_3^- \rightarrow 2H_2O + 3Cu^{2+} + 2NO$ [CL2] (4)
✓✓ ✓✓

ASSESSMENTS