SENIOR SECONDARY IMPROVEMENT PROGRAMME 2013

education

Department: Education

GAUTENG PROVINCE

GRADE 12

PHYSICAL SCIENCES

TEACHER NOTES

The SSIP is supported by

TABLE OF CONTENTS

TEACHER NOTES

SESSION 8

TOPIC: CHEMICAL EQUILIBRIUM

Teacher Note: Please ensure that the learners understand and know the factors affecting the rate of a reaction very well before attempting this section on chemical equilibrium. The only factors affecting chemical equilibrium are temperature, pressure and concentration.

LESSON OVERVIEW

1.	Introduction:	5 minutes
2.	Typical exam questions	50 minutes
3.	Review/solutions/memo	35 minutes

SECTION A: TYPICAL EXAM QUESTIONS

QUESTION 1: 5 minutes

Consider the following equilibrium reaction:

$$N_{2\,(g)} + 3\,H_{2(g)} \leftrightarrows 2NH_{3\,(g)} \quad \triangle H< 0$$

9 mol of N_2 and 15 mol of H_2 are pumped into a 500cm^3 container at room temperature.

The temperature of the gas mixture is now raised to 405°C resulting in 8 mol NH_3 being present at equilibrium.

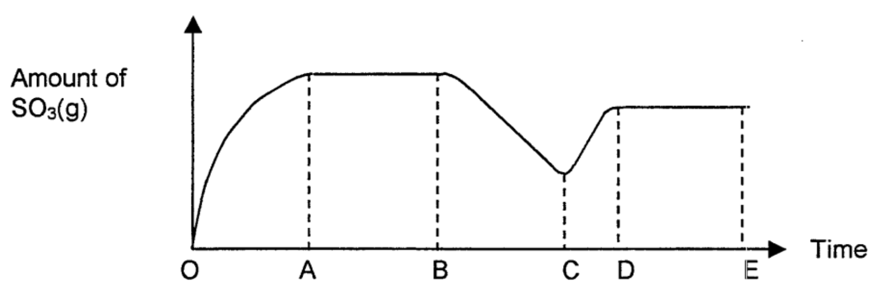
Calculate the value of K_c at 405°C0 [6]

QUESTION 2: 18 minutes

Consider the following reaction:

$$2SO_{2\,(g)} + O_{2\,(g)} \rightleftharpoons 2SO_{3\,(g)} \qquad \Delta H < 0$$

A graph of the AMOUNT of $SO_{3\,(g)}$ was plotted against time as shown below:



2.1 How does the rate of the forward reaction compare to the rate of the reverse reaction during the following intervals?:(Write down only GREATER THAN, EQUAL TO or LESS THAN.)

2.1.1 OA (1)
2.1.2 BC (1)
2.1.3 DE (1)

2.2 Initially 8,0 moles of $SO_{2\,(g)}$ and x moles of $O_{2\,(g)}$ are placed in a 2,0 dm^3 empty container and sealed at a specific temperature. At equilibrium 6,0 moles of $SO_{3\,(g)}$ are present in the container. If the K_C value of the above equilibrium at this temperature is 9, calculate x, that is, the initial amount of $O_{2\,(g)}$ that was placed in the container. (6)

2.3 If the changes in the graph from B to D are due to changes in the TEMPERATURE, at which points (B, C or D) will the temperature be the lowest? (1)

2.4 Give an explanation for the answer to 2.3. (2)

2.5 At which point (B, C or D) will the K_C value be the greatest? (1)

2.6 Give an explanation for the answer to 2.5. (2)

2.7 If the changes in the graph from B to D are due to PRESSURE changes, at which point (B, C or D) will the pressure be the lowest? (1)

2.8 Give an explanation for the answer to 2.7. (2)

[18]

QUESTION 3: 7 minutes

3. A mixture of 5 moles of $H_{2\,(g)}$ and 10 moles of $I_{2\,(g)}$ is placed in a $5dm^3$ container and is allowed to reach equilibrium at 448^oC. The equation for the equilibrium reaction is:

$$H_2\,(g) + I_{2\,(g)} \rightleftharpoons 2HI_{(g)}$$

At equilibrium the concentration of the $HI_{(g)}$ is equal to 1,88 $mol.dm^{-3}$.

3.1 Calculate the value of K_c at 448^oC. (6)

3.2 While the system is in equilibrium, $H_{2\,(g)}$ is added to it. Explain by using Le Chatelier's principle how the addition of $H_{2\,(g)}$ influences the number of moles of $HI_{(g)}$ when a new equilibrium has been established. Assume that the temperature is kept constant (3)

[9]

QUESTION 4: 20 minutes *(Physical Sciences Paper 2 DoE Feb – March 2010)*

Combustion in air at high temperatures produces oxides of nitrogen of which nitrogen dioxide ($NO_2(g)$), is the most common. Natural sources of nitrogen dioxide include lightning and the activity of some soil bacteria. These natural sources are small compared to emissions caused by human activity.

NO_2 can irritate the lungs and cause respiratory infection. When $NO_2(g)$ dissolves in rainwater in air it forms nitric acid which contributes to acid rain.

4.1 State TWO human activities that contribute to high nitrogen dioxide levels in the atmosphere. (2)

4.2 Write a balanced equation to show how nitric acid forms from nitrogen dioxide in air. (2)

4.3 High levels of nitrogen dioxide in the atmosphere can result in damage to crops and eventually food shortages. Briefly state how high levels of nitrogen dioxide can damage crops. (1)

4.4 Nitric acid can cause corrosion of copper cables whilst hydrochloric acid does no harm to copper cables. Refer to the relative strengths of the oxidising agents involved to explain this phenomenon (3)

4.5 2 mol of $NO_2(g)$ and an unknown amount of $N_2O_4(g)$ are sealed in a 2 dm^3 container, that is fitted with a plunger, at a certain temperature. The following reaction takes place:

$$2NO_2(g) \rightleftharpoons N_2O_4(g)$$

At equilibrium it is found that the NO_2 concentration is 0,4 $mol \cdot dm^{-3}$. The equilibrium constant at this temperature is 2.

4.5.1 Calculate the initial amount (in mol) of $N_2O_4(g)$ that was sealed in the container. (9)

The plunger is now pushed into the container causing the pressure of the enclosed gas to increase by decreasing the volume.

4.5.2 How will this change influence the amount of nitrogen dioxide at equilibrium? Only write down INCREASES, DECREASES or REMAINS THE SAME. (1)

4.5.3 Use Le Chatelier's principle to explain your answer to QUESTION 4.5.2. (2)

[21]

SECTION B: SOLUTIONS AND ANSWERS TO SECTION A

QUESTION 1

	N_2	H_2	NH_3
Initial number of mole (mol)	9	15	0
Number of moles used/formed (mol)	4	12	8
Number of moles at equilibrium (mol)	5	3	8
Equilbrium concentration ($mol \cdot dm^{-3}$) c = n/V	10√	6√	16√

$$K_c = \frac{[NH_3]^2}{[N_2][H_2]^3} \surd$$

$$= \frac{16^2}{(10)(6)^3} \surd$$

$$=0,12 \surd$$

[6]

QUESTION 2

2.1.1. greater than √ (1)

2.1.2. less than√ (1)

2.1.3. equal to√ (1)

2.2.

	SO_2	O_2	SO_3
Initial number of mole (mol)	8	x	0
Number of moles used/formed (mol)	6	3	6
Number of moles at equilibrium (mol)	2	x - 3	6
Equilbrium concentration ($mol \cdot dm^{-3}$) c = n/V	1√	$\frac{x-3}{2}$√	3√

$$K_c = \frac{[SO_3]^2}{[O_2][SO_2]^2} \checkmark$$

$$9 = \frac{3^2}{\left(\frac{x-3}{2}\right)(1)^2} \checkmark$$

$$x = 5 \text{ mol } \checkmark$$ (6)

2.3. B√ (1)
2.4. Forward is exo. √ Exo is favoured at colder temperatures√ (2)
2.5. B√ (1)
2.6. More product √therefore larger Kc√ (2)
2.7. C√ (1)
2.8. Low pressure favours reverse reaction √since more gas moles are at reactants side√ (2)

[18]

QUESTION 3

3.1

	H_2	I_2	HI
Initial number of mole (mol)	5	10	0
Number of moles used/formed (mol)	4,7	4,7	9,4
Number of moles at equilibrium (mol)	0,3	5,3	9,4√
Equilibrium concentration ($mol{\cdot}dm^{-3}$) c = n/V	0,06√	1,06√	1,88

$$K_c = \frac{[HI]^2}{[H_2][I_2]} \checkmark$$

$$= \frac{(1{,}88)^2}{(0{,}06)(1{,}06)} \checkmark$$

$$= 55{,}57 \checkmark$$ (6)

3.2. An increase in H_2 will according to Le Chatelier's Principle cause the equilibrium to shift so as to decrease the H_2 by forming more product. √This favours the forward reaction. √ In addition an increase in H_2 increases the pressure which will also favour the forward reaction to produce lower moles of gas. √ (3)

[9]

QUESTION 4

4.1 Any two

- Burning of fuel when cars are used - exhaust gases contains oxides of nitrogen. ✓
- Burning of coal (generation of electricity)/nitrogen containing compounds/organic waste. ✓
- Factories and other industrial plants that emits nitrogen oxides into the atmosphere as waste. (2)

4.2 $4NO_2(g) + O_2(g) + 2H_2O(\ell)$ ✓ $\rightarrow 4HNO_3(aq)$ ✓ bal ✓

OR

$3NO_2(g) + H_2O(\ell)$ ✓ $\rightarrow 2HNO_3(aq) + NO(g)$ ✓ bal ✓ (3)

4.3 $NO_2(g)$ dissolves in rainwater to form acid rain that burns/destroys crops. ✓ (1)

4.4 $NO_3^-(aq)$ is a strong oxidising agent ✓

and oxidise Cu (to Cu^{2+}). ✓

$H^+(aq)$ is not a strong enough oxidising agent ✓ and cannot oxidise Cu to Cu^{2+}. (3)

4.5.1

	$2NO_2$	N_2O_4
Initial number of mole (mol)	2	x
Number of moles used/formed (mol)	-1,2✓	+0,6 ✓
Number of moles at equilibrium(mol)	0,8✓	x + 0,6 ✓
Equilibrium concentration (mol·dm^{-3})	0,4	$\frac{x+0,6}{2}$ ✓

+

$$K_c = \frac{[N_2O_4]}{[NO_2]^2} ✓ \therefore 2 ✓ = \frac{\left(\frac{x+0,6}{2}\right)}{(0,4)^2} ✓ \therefore x = 0,04 \text{ mol}·✓$$ (9)

4.5.2 Decreases ✓ (1)

4.5.3 Expressions with the same meaning as "forward reaction is favoured

Equilibrium position shifts to the right. / Equilibrium lies to the right

Accept: the equilibrium shift to the right (2)

[21]

SECTION C: HOMEWORK

QUESTION 1: 17 minutes *(Taken from DoE Physical Sciences Paper 2 Exemplar 2008)*

1.1 Many industries use ammonia as a coolant in their plants. Ammonia is also used in the fertiliser industry. The ammonia is manufactured by the Haber process in the presence of a catalyst at a temperature of 500°C. The equilibrium process may be represented by the equation below:

$$N_2 (g) + 3H_2 (g) \leftrightharpoons 2NH_3 (g) \qquad \Delta H < 0$$

The temperature is now decreased to 100°C. Explain whether or not the ammonia can now be produced profitably. (3)

1.2 Ammonia is used in the industrial preparation of nitric acid. One of the reactions in this process, shown below, reached equilibrium in a closed container at a temperature of 1 000 °C.

$$4NH_3 (g) + 5O_2 (g) \leftrightharpoons 4NO (g) + 6H_2O (g)$$

The initial concentrations of NH_3 (g) and O_2 (g) were both equal to 1 mol·dm^{-3} .At equilibrium it is found that the concentration of NH_3 (g) has changed by 0,25 mol·dm^{-3}.

1.2.1 Calculate the value of the equilibrium constant at the given temperature. (9)

1.2.2 Is the yield of NO high or low at this temperature? Give a reason for your answer (3)

[15]

QUESTION 2: 8 minutes *(Taken from DoE Physical Science Paper 2 November 2004)*

7 mol of nitrogen gas and 2 mol of oxygen gas are placed in an empty container of volume 2 dm^3. The container is sealed and the following equilibrium is established:

$$N_2 (g) + O_2 (g) \leftrightharpoons 2NO (g)$$

At equilibrium, there is 0,4 mol NO (g) present. Determine the value of K_c at this temperature. [6]

SECTION D: SOLUTIONS AND HINTS TO HOMEWORK

QUESTION 1

1.1 The forward reaction is exothermic. ✓Thus, lowering the temperature favours the forward, exothermic reaction and the ammonia will now have a higher yield. ✓ However, the rate of reaction will be lowered and this will lead to the ammonia production being unprofitable. ✓ (3)

1.2.1

	NH_3	O_2	NO	H_2O
Initial concentration ($mol \cdot dm^{-3}$)	1	1	0	0
Change in concentration ($mol \cdot dm^{-3}$)	0,25	0,3125	0,25	0,375
Equilibrium concentration ($mol \cdot dm^{-3}$)	0,75✓	0,6875✓	0,25✓	0,375✓

$$K_c = \frac{[NO]^4[H_2O]^6}{[NH_3]^4[O_2]^5} \checkmark$$

$$= \frac{(0,25)^4(0,375)^6 \checkmark}{(0,75)^4(0,6875)^5 \checkmark}$$

$$= 2,2 \times 10^{-4} \checkmark\checkmark$$ (9)

1.2.2 Low. ✓ The small equilibrium constant value indicates that the equilibrium lies towards the reactants side ✓ and that there are more reactant molecules in the reaction mixture at equilibrium, thus NO will have a low yield. ✓ (3)

[15]

QUESTION 2

	N_2	O_2	NO
Initial number of mole (mol)	7	2	0
Number of moles used/formed (mol)	0,2	0,2	0,4
Number of moles at equilibrium (mol)	6,8	1,8	0,4
Equilbrium concentration ($mol \cdot dm^{-3}$) $c = n/V$	3,4✓	0,9✓	0,2✓

$$K_c = \frac{[NO]^2}{[N_2][O_2]} \checkmark$$

$$= \frac{(0,2)^2}{(3,4)(0,9)} \checkmark$$

$$= 0,013 \checkmark$$ **[6]**

SESSION 9

TOPIC: ELECTROLYTIC AND GALVANIC CELLS

Teacher Note: Ensure that learners understand the difference between an atom and an ion. Revise oxidation and reduction, and the types of energy transfers that take place in electrolytic and electrochemical cells.

LESSON OVERVIEW

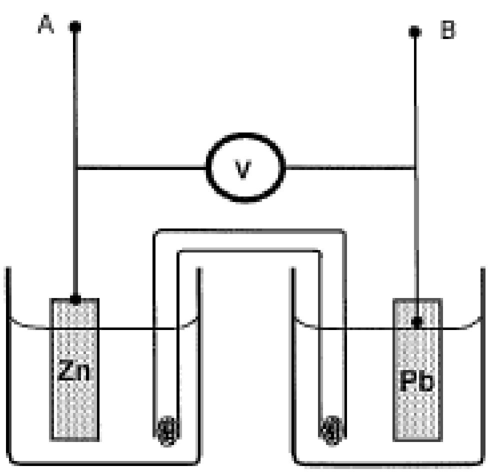
1. Introduce session: 10 minutes
2. Typical exam questions: 55 minutes
3. Review/solutions/memo: 25 minutes

SECTION A: TYPICAL EXAM QUESTIONS

QUESTION 1: 25 minutes

(Taken from DoE Physical Sciences Preparatory Examination Paper 2 2008)

Tina wants to investigate the effect of the area of the metal plates used as electrodes in a galvanic cell on the emf of the cell. She sets up the following Zn/Pb cell under standard conditions and measures the emf.



1.1 Which electrode will show an increase in mass when this cell is functioning? (1)

1.2 Write down the equation for the half-reaction occurring at the anode. (2)

1.3 Calculate the emf that you would expect Tina to read on the voltmeter. (4)

1.4 Name two variables that should be controlled during this investigation. (2)

1.5 Write down the overall nett ionic equation. (3)

1.6 Write down the cell notation for the reaction. (3)

1.7 Tina now replaces the two metal plates with ones of a larger surface area, and takes the reading again.

1.7.1 How would you expect the new emf to compare with the one calculated in Question 1.3? (Write only smaller than, larger than or equal to.) (1)

1.7.2 Explain your answer to question 1.7.1. (2)

1.8 Tina now connects a resistor of low resistance across the terminals A and B. She notes that the reading on the voltmeter immediately drops.

1.8.1 Give a reason for this observation. (2)

1.8.2 After some time she observes a further gradual drop in the reading on the voltmeter.

1.8.3 Give a reason for this observation. (2)

[22]

QUESTION 2: 15 minutes

(Taken from DoE Physical Sciences November Examination Paper 2 2010)

The cell notation of a standard galvanic (voltaic) cell containing an unknown metal electrode **X** is shown below.

$$X(s) \mid X^{3+}(1\ mol{\cdot}dm^{-3}) \parallel Pb^{2+}(1\ mol{\cdot}dm^{-3}) \mid Pb(s)$$

2.1 Name the component of the cell represented by the double vertical lines (||) in the above cell notation. (1)

2.2 State the TWO standard conditions that are applicable to the $Pb^{2+}|Pb$ half-cell. (2)

2.3 Identify the oxidising agent in the above cell. (1)

2.4 The initial reading on a voltmeter connected across the electrodes of the above cell is 1,53 V. Identify metal **X** by calculating the standard reduction potential of the unknown metal **X**. (5)

2.5 Write down the balanced equation for the net (overall) reaction taking place in this cell. Omit the spectator ions. (3)

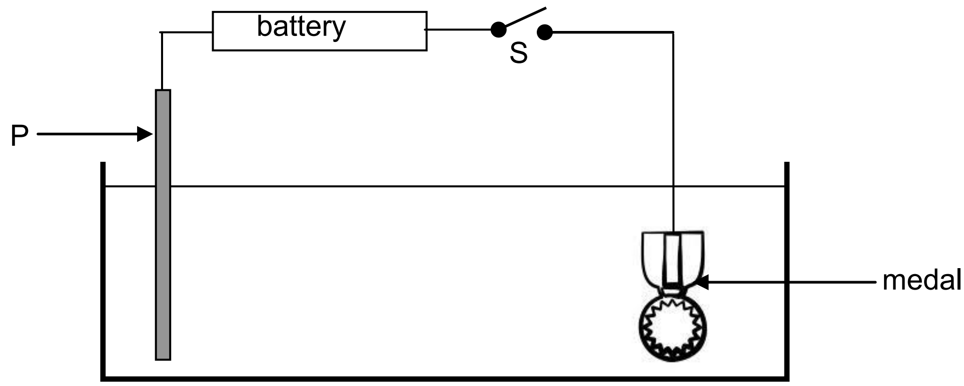
2.6 How will the initial voltmeter reading be affected if the concentration of the electrolyte in the $X(s)|X^{3+}(aq)$ half-cell is increased? Write down only INCREASES, DECREASES or REMAINS THE SAME. (2)

2.7 Write down the value of the reading on the voltmeter when the cell reaction has reached equilibrium. (2)

[16]

QUESTION 3: 15 minutes

The diagram below represents a cell that can be used to electroplate a tin medal with a thin layer of silver to improve its appearance.



3.1 Which one of **P** or the **MEDAL** is the anode in this cell? (1)

3.2 Write down the following

3.2.1 NAME or SYMBOL of the element of which electrode **P** is composed (1)

3.2.2 NAME or FORMULA of the electrolyte that has to be used to achieve the desired results (1)

3.3 Switch **S** is now closed. Write down the visible changes that will occur at the following:

3.3.1 Electrode **P** (1)

3.3.2 The medal (1)

3.4 Write down the equation for the half-reaction to support the answer to QUESTION 3.3.2 (2)

3.5 How will the concentration of the electrolyte change during the electroplating process? Write down only INCREASES, DECREASES or REMAINS THE SAME. (1)

3.6 You want to coat the medal with copper instead of silver. State TWO changes that you will make to the above cell to obtain a medal coated with copper (2)

[10]

SECTION B: SOLUTIONS AND HINTS TO SECTION A

QUESTION 1

1.1 Pb √ (1)

1.2 $Zn \rightarrow Zn^{2+} + 2e^{-}$ √√ (2)

1.3 $E^{\theta}_{cell} = E^{\theta}_{cathode} - E^{\theta}_{anode}$ √
$= -0,13$ √ $- (-0,76)$√
$E^{\theta}_{cell} = 0,63$ V √ (4)

1.4 Temperature √and initial concentration of electrolytes. √ (2)

1.5 $Zn + Pb^{2+} \rightarrow Zn^{2+} + Pb$
(√ for reactants, √ for products, √ for balancing) (3)

1.6 $Zn\ (s) / Zn^{2+}(aq)\ //\ Pb^{2+}(aq) / Pb\ (s)$
√ √ √ (3)

1.7.1 equal to√ (1)
1.7.2 area/size of electrodes has no effect on the emf of a cell. √√ (2)

1.8.1 The cell has internal resistance. √√ (2)
1.8.2 The emf decreases as the concentration of Pb^{2+} (aq) decreases. √√ (2)
OR
The cell is running flat as the electrolyte solution in the Pb cell decreases. **[22]**

QUESTION 2

2.1 Salt bridge √ (1)
2.2 Concentration of the electrolyte – 1 mol·dm-3 √
Temperature – 25 °C/298 K√ (2)
2.3 Pb2+ √/ lead(II) ions / lead ions (1)
2.4 $E^{o}_{cell} = E^{o}_{cathode} - E^{o}_{anode}$ √
1,53 √= (-0,13) √- E^{o}_{anode}
$E^{o}_{anode} = -1,66$ (V) √
√ unknown metal X is Aℓ √ (5)
2.5 $2A\ell + 3Pb^{2+} \rightarrow 2A\ell^{3+} + 3Pb$
(reactants √ ; products√ ; bal√) (3)
2.6 Decreases √√ (2)
2.7 0 V√ √ (2)
[16]

QUESTION 3

3.1 P √ (1)
3.2.1 Ag / Silver √ (1)
3.2.2 Silver nitrate / $AgNO_3$ √ or silver ethanoate /acetate /CH_3COOAg.
(These are the only two soluble silver salts.) (1)
3.3.1 Silver /metal bar becomes eroded /pitted/ smaller / thinner /eaten away √ (1)
3.3.2 A (silver) layer forms on the medal. √ (1)
3.4 $Ag^+ + e^- \rightarrow Ag$ √√ (2)
3.5 Remains the same. √ (1)
3.6 Replace the silver solution with a copper solution√/soluble copper salt.
Replace the silver bar/electrode P/anode with a copper bar. √ (2)
[10]

SECTION C: HOMEWORK

QUESTION 1: 25 minutes *(Taken from DoE Physical Sciences Paper 2 November 2008)*

1.1 Rusting is an unwanted redox reaction. Iron rusts when exposed to oxygen and moisture. The unbalanced ionic equation for one reaction that occurs during rusting, is represented below:

$$Fe\,(s) + O_2\,(g) + H_2O\,(l) \rightarrow Fe^{2+}\,(aq) + OH^-\,(aq)$$

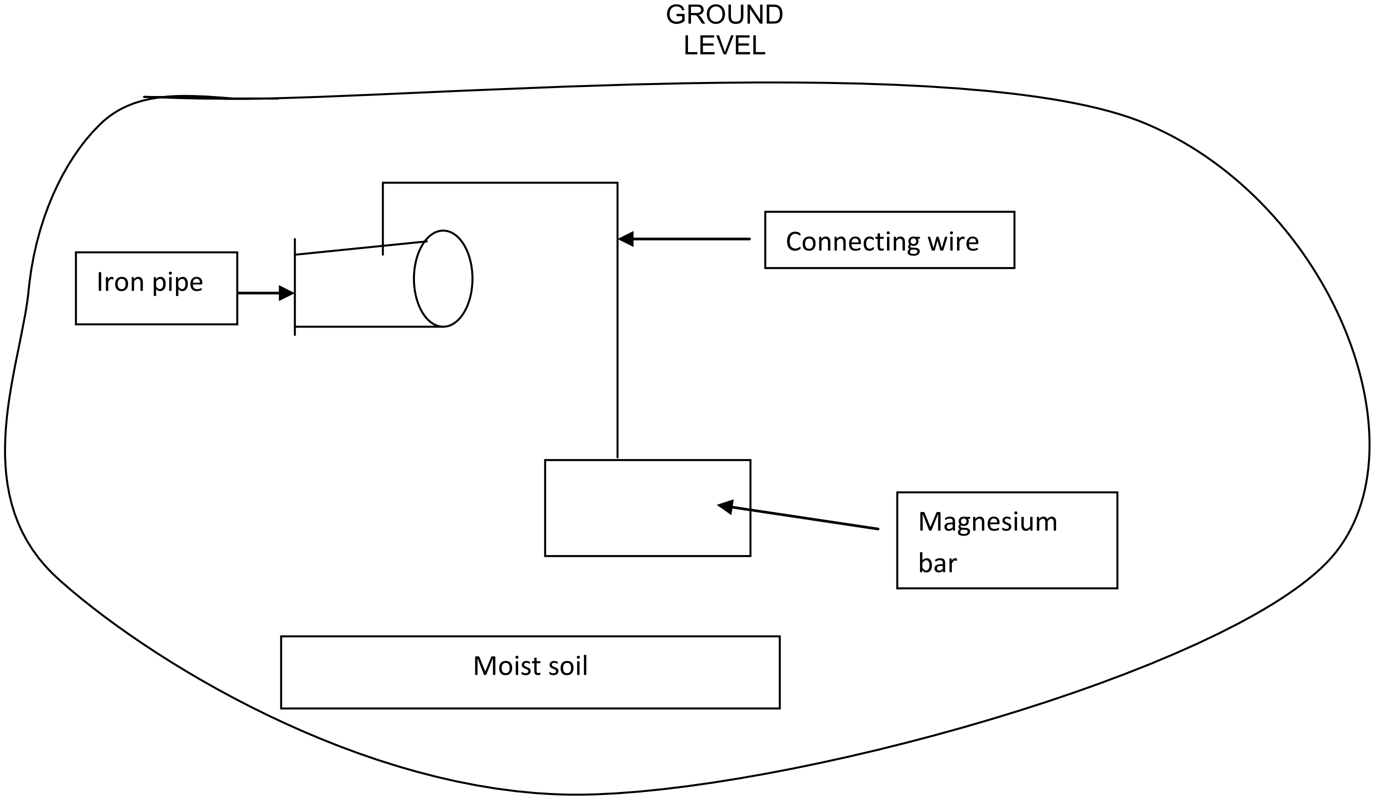
Use the table of Standard Reduction Potentials (Table 4A or 4B) to answer the following questions for this reaction:

1.1.1 Write down the oxidation half-reaction. (2)

1.1.2 Write down the NAME of the substance that is reduced. (1)

1.1.3 Perform a calculation to verify that this reaction is spontaneous. (5)

1.2 Magnesium is used to protect underground iron pipes against rusting. The diagram below shows an iron pipe connected to a magnesium bar.



1.2.1 Use the Table of Standard Reduction Potentials (Table 4A or 4B) to explain why the magnesium can be used to protect an iron pipe against rusting. (2)

1.2.2 The iron pipe in contact with the magnesium bar forms an electrochemical cell. What serves as the salt bridge of this cell? (2)

1.2.3 Give a reason why the magnesium bar must be replaced after some time? (1)

1.2.4 Write down a half-reaction to support your answer to Question 1.2.3. (2)

1.2.5 Name TWO other methods that can be used to protect iron pipes against rust. (2)

1.2.6 State ONE advantage and ONE disadvantage of using plastic pipes instead of iron pipes. (2)
[19]

SECTION D: SOLUTIONS TO HOMEWORK

QUESTION 1

1.1.1 $Fe \rightarrow Fe^{2+} + 2e^{-}$ √√ (2)
1.1.2 Oxygen √ (1)
1.1.3 $E^{\theta}_{cell} = E^{\theta}_{cathode} - E^{\theta}_{anode}$ √
$= 0,4$ √ $- (-0,44)$√
$E^{\theta}_{cell} = 0,84$ V √
Because the emf is positive, the reaction is spontaneous. √ (5)
1.2.3 Mg is a stronger reducing agent √than Fe and will be oxidised √ (2)
Or Mg loses electrons more easily than Fe and becomes oxidised.
Or Fe is a weaker reducing agent than Mg and will not be oxidised.
1.2.2 Electrolytes in the soil √√or salts dissolved √in the moist soil. √ (2)
1.2.3 Mg is oxidised or becomes corroded or used up. √ (1)
1.2.4 $Mg \rightarrow Mg^{2+} + 2e^{-}$ √√ (2)
1.2.5 Any two:
- Paint√
- Electroplating√
- Oil or waterproofing
- Galvanising
- Plastic coating (2)

1.2.6 Advantage: ANY ONE:
- Plastic is cheaper√
- Does not rust

Disadvantage: Any one:
- Not degradable√
- Not as strong as iron (2)

[19]

SESSION 10

TOPIC: CONSOLIDATION EXERCISES ON MECHANICS AND MATTER AND MATERIALS

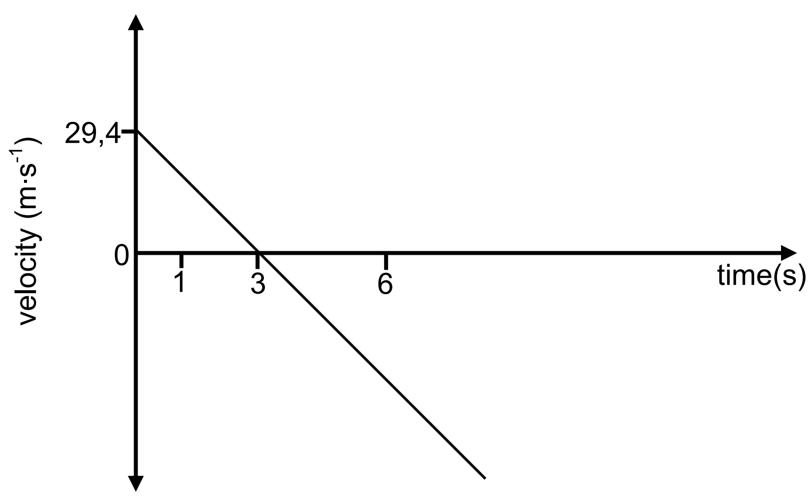
LESSON OVERVIEW

1. Typical exam questions: 55 minutes
2. Review/solutions/memo: 35 minutes

SECTION A: TYPICAL EXAM QUESTIONS

QUESTION 1: 20 minutes *(Taken from the NSC Physical Sciences P1 Nov 2010)*

A man fires a projectile **X** vertically upwards at a velocity of 29,4 m·s^{-1} from the EDGE of a cliff of height 100 m. After some time the projectile lands on the ground below the cliff. The velocity-time graph below (NOT DRAWN TO SCALE) represents the motion of projectile **X**. (Ignore the effects of friction.)



1.1 Use the graph to determine the time that the projectile takes to reach its maximum height. (A calculation is not required.) (1)

1.2 Calculate the maximum height that projectile **X** reaches above the ground. (4)

1.3 Sketch the position-time graph for projectile **X** for the period t = 0 s to t = 6 s. USE THE EDGE OF THE CLIFF AS ZERO OF POSITION.

Indicate the following on the graph:

- The time when projectile **X** reaches its maximum height
- The time when projectile **X** reaches the edge of the cliff (4)

1.4 One second (1 s) after projectile **X** is fired, the man's friend fires a second projectile **Y** upwards at a velocity of 49 m·s^{-1} FROM THE GROUND BELOW THE CLIFF.

The first projectile, **X**, passes projectile **Y** 5,23 s after projectile **X** is fired. (Ignore the effects of friction.)

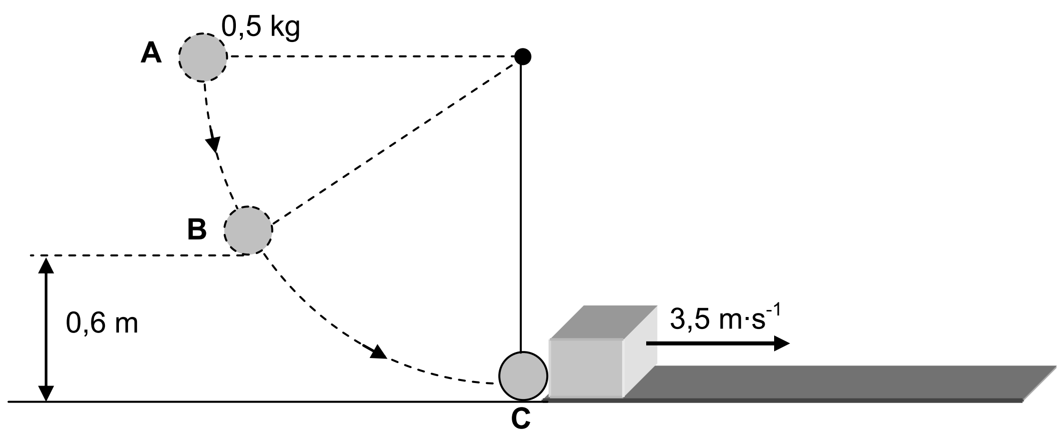
Calculate the following:

1.4.1 The velocity of projectile **X** at the instant it passes projectile **Y** (5)

1.4.2 The velocity of projectile **X** RELATIVE to projectile **Y** at the instant it passes projectile **Y** (5)
[19]

QUESTION 2: 1 5 minutes *(Taken from the NSC Physical Sciences P1 Nov 2010)*

A steel ball of mass 0,5 kg is suspended from a string of negligible mass. It is released from rest at point **A**, as shown in the sketch below. As it passes through point **B**, which is 0,6 m above the ground, the magnitude of its velocity is 3 m·s^{-1}. (Ignore the effects of friction.)



2.1 Write down the principle of the conservation of mechanical energy in words. (2)

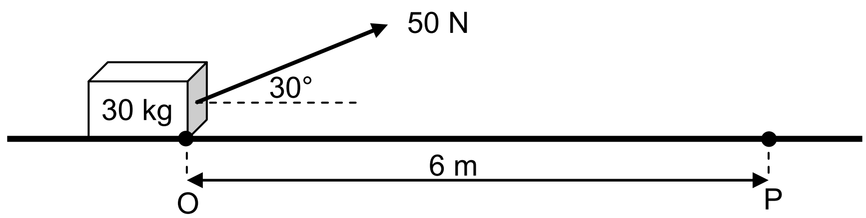
2.2 Calculate the mechanical energy of the steel ball at point **B**. (4)

As the steel ball swings through its lowest position at point **C**, it collides with a stationary crate of mass 0,1 kg. Immediately after the collision, the crate moves at a velocity of 3,5 m·s^{-1} to the right.

2.3 Calculate the velocity of the steel ball immediately after the collision. (7)
[13]

QUESTION 3: 20 minutes *(Taken from the NSC Physical Sciences P1 Nov 2010)*

A worker pulls a crate of mass 30 kg from rest along a horizontal floor by applying a constant force of magnitude 50 N at an angle of 30° to the horizontal. A frictional force of magnitude 20 N acts on the crate whilst moving along the floor.



3.1 Draw a labelled free-body diagram to show ALL the forces acting on the crate during its motion (4)

3.2 Give a reason why each of the vertical forces acting on the crate do NO WORK on the crate. (2)

3.3 Calculate the net work done on the crate as it reaches point P, 6 m from the starting point O. (4)

3.4 Use the work-energy theorem to calculate the speed of the crate at the instant it reaches point P (3)

3.5 The worker now applies a force of the same magnitude, but at a SMALLER ANGLE to the horizontal, on the crate.
How does the work done by the worker now compare to the work done by the worker in QUESTION 3.3? Write down only GREATER THAN, SMALLER THAN or EQUAL TO.

Give a reason for the answer. (No calculations are required.) (2)

[15]

SECTION B: SOLUTIONS AND HINTS TO SECTION A

QUESTION 1

1.1 3 seconds✓ (1)

1.2 Either:

Area between graph and time axis

Δy = (area of triangle)/ ½ bh ✓

= ½ (3)(29,4) ✓

= 44,1 m

Maximum height above ground:

100 +✓ 44,1 = 144,1 m ✓

OR From edge of cliff to max height.

(Upward positive)

$v_f^2 = v_i^2 + 2a\Delta y$ ✓

$\therefore\ 0^2 = 29{,}4^2 + 2(-9{,}8)\Delta y$✓

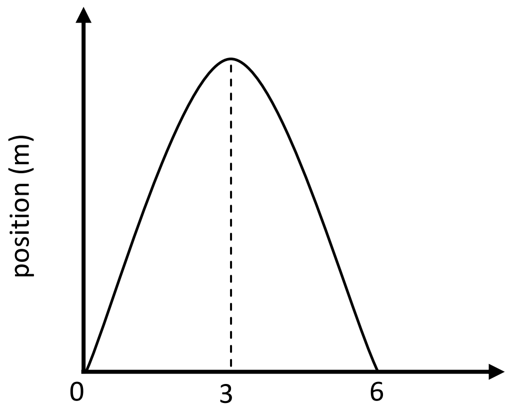
$\therefore\ \Delta y = 44{,}1$ m (43,22m)

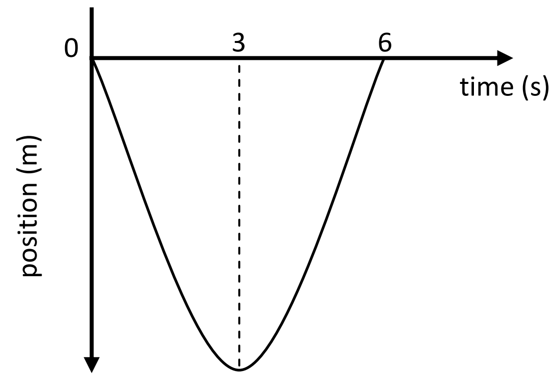
Maximum height above ground:

100 +✓ 44,1 = 144,1 m✓ (4)

1.3

Checklist: Criteria for graph	Marks
Correct shape	✓
t = 3 s at maximum height	✓
t = 6 s at y = 0 m	✓
Graph starts at y = 0□m □t t = 0 s	✓





(4)

1.4.1

OPTION 1:

Upward positive:

$v_f = v_i + a\Delta t$ ✓

$= 29{,}4$ ✓ $+ (-9{,}8)(5{,}23)$ ✓

$= -21{,}85\ m\cdot s^{-1}$ ✓downwards ✓

Downward positive:

$v_f = v_i + a\Delta t$ ✓

$= -29{,}4$ ✓ $+ (9{,}8)(5{,}23)$ ✓

$= 21{,}85\ m\cdot s^{-1}$ ✓downwards ✓

OR

OPTION 2

$\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$

$= 29{,}4\ (5{,}23) + ½\ (-9{,}8)(5{,}23)^2$

$= 19{,}73\ m$ (16,9975 m)

$v_f^2 = v_i^2 + 2a\Delta y$

$= 29{,}4^2$ ✓ $+ 2(-9{,}8)(19{,}73)$ ✓

$\therefore v_f = 21{,}85\ m\cdot s^{-1}$ ✓downwards ✓

(5)

1.4.2 **Downward positive**

$\Delta t = (5,23 - 1)$ ✓ $= 4,23$ s

$v_f = v_i + a\Delta t$ ✓

$= -49 + (9,8)(4,23)$ ✓

$= -7,55 \text{ m·s}^{-1}$

$v_f = 7,55 \text{ m·s}^{-1}$ upwards

$v_{XY} = v_{XG} + v_{GY}$

$= 21,85 + (7,55)$

$v_{XY} = 29,40 \text{ m·s}^{-1}$ ✓downwards✓

$v_{XY} = v_X - v_Y$ (vector difference)

$= 21,85 - (-7,55)$

$= 29,40 \text{ m·s}^{-1}$ ✓downwards✓

$v_{XG} = v_{XY} + v_{YG}$

$21,85 = v_{XY} + (-7,55)$

$= 29,40 \text{ m·s}^{-1}$ ✓downwards✓ (5)

[19]

QUESTION 2

2.1 The sum of the kinetic and (gravitational) potential energy is conserved / constant / remains the same / does not change✓ in an isolated / closed / system / no external work done / only conservative forces act on the system.✓

OR

The (total) mechanical energy is conserved/ constant✓ in an isolated system.✓ (2)

2.2 $E_{mech} = U + K$ or $E_p + E_k$

$= mgh + ½ mv^2$ ✓

$= (0,5)(9,8)(0,6)$ ✓ $+ ½ (0,5)(3)^2$ ✓

$= 5,19$ J ✓

(4)

2.3

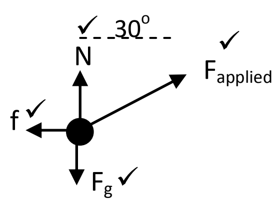
$(U + K)_B = (U + K)_C$ ✓
$mgh_B + ½ \, m v_B^2 = mgh_C + ½ \, m v_C^2$
$5,19$ ✓ $= 0 + ½ (0,5)v^2$ ✓
$\therefore v = 4,56 \text{ m·s}^{-1}$ $(4,58 \text{ m·s}^{-1})$

$\Sigma p_{before} = \Sigma p_{after}$
$m_b v_{ib} + m_c v_{ic} = m_b v_{fb} + m_c v_{fc}$ ✓
$(0,5)(4,56) + 0$ ✓ $= (0,5)v_{fb} + (0,1)(3,5)$ ✓
$\therefore v_{fb} = 3,86 \text{ m·s}^{-1}$ ✓(to the right) (7)

[13]

QUESTION 3

3.1



N = normal force

f_f = force of friction

$F_{applied}$ = applied force

F_g = force of gravity (4)

3.2 W = FΔx cos90°✓= 0✓
OR
They (normal force and the gravitational force) are perpendicular /at 90° to the (direction of the) displacement / motion / Δx✓✓of the crate.
OR
The angle between the force and displacement / motion / Δx is 90°.✓✓
OR
The crate moves horizontally and the forces act vertically.✓✓ (2)

3.3
$W_{net} = W_{appl} + W_f$ ✓

$= F_{app}\Delta x \cos\theta + f\Delta x \cos\theta$

$= (50)(6)(\cos 30°)$✓ $+ (20)(6)(\cos 180°)$ ✓

$= 259{,}81 + (-120)$

$W_{net} = 139{,}81$ J ✓

(4)

3.4 $W_{net} = \Delta E_k$ ✓

$= \frac{1}{2} mv_f^2 - \frac{1}{2} mv_i^2$

$139{,}81 = \frac{1}{2}(30)v_f^2 - 0$ ✓

$v_f = 3{,}05$ m·s^{-1} ✓ (3)

3.5 Greater than ✓ (Accept any equivalent word e.g. larger, etc.)

The horizontal component (of the force) / force in direction of motion will now be greater / F_{net} will now be greater.✓

(2)

[15]

SECTION C: HOMEWORK

QUESTION 1: 12 minutes

The photoelectric threshold frequency of copper is 9,4 X 10^{14}Hz.

1.1 What is the work function of copper? (3)

1.2 With what maximum kinetic energy will electrons be ejected when light of frequency 2,2 x 10^{15} Hz is shone onto the copper. (5)

1.3 What would the velocity of the electrons as they are ejected from the metal be? (4)
[12]

QUESTION 2: 11 minutes

2. The threshold frequency of a certain metal is 4,47 x 10^{15} Hz.

2.1 Calculate the work function of the metal. (3)

2.2 If light of wavelength 234 nm shines on the metal, find the maximum kinetic energy of the photoelectrons. (8)
[11]

QUESTION 3: 7 minutes

The hydrogen alpha line in the solar spectrum has a wavelength of 656,285 nm. Remember that all stars are simply similar in nature to our sun and they should contain the same elements. The hydrogen alpha spectral line, that is detected on earth, in the light from a nearby star has a wavelength of 656,315 nm.

What can we conclude about the motion of this star? Briefly explain your answer. [5]

SECTION D: SOLUTIONS TO HOMEWORK

QUESTION 1

1.1 W = hf ✓= $6{,}63 \times 10^{-34} \times 9{,}4 \times 10^{14}$✓
$= 6{,}2 \times 10^{-19}$ J✓ (3)

1.2 hf = W + E_K ✓

$6{,}63 \times 10^{-34}$ ✓ $\times 2{,}2 \times 10^{15}$✓ $= 6{,}2 \times 10^{-19} + E_K$✓

$E_K = 8{,}39 \times 10^{-19}$ J✓ (5)

1.3 $E_K = ½ mv^2$ ✓
$8{,}32 \times 10^{-19}$✓ $= ½ (9{,}1\times10^{-31}) v^2$ ✓ (m is the mass of an electron)

$v = 1{,}35 \times 10^6$ m·s^{-1} ✓ (4)
[12]

QUESTION 2

2.1 W = hf ✓= $6{,}63 \times 10^{-34} \times 4{,}47 \times 10^{15}$✓
$= 2{,}96 \times 10^{-19}$ J✓ (3)

2.2 $v = \lambda f$ ✓
3×10^8 ✓= $(234 \times 10^{-9})f$✓

$f = 1{,}3 \times 10^{15}$ Hz ✓

hf = W + E_K ✓

$6{,}63 \times 10^{-34} \times 1{,}3 \times 10^{15}$ ✓= $7{,}3 \times 10^{-19} + E_K$ ✓

$E_K = 1{,}32 \times 10^{-19}$ J✓ (8)
[11]

QUESTION 3

The longer wavelength of the star in comparison to the sun suggests red shift. ✓ This is the Doppler effect ✓in relation to light. As the star moves away from the earth, ✓the waves spread apart✓ so we detect a longer wavelength. ✓ **[5]**

SESSION 11

TOPIC: CONSOLIDATION EXERCISES ON SOUND, DOPPLER EFFECT AND LIGHT

SECTION A: TYPICAL EXAM QUESTIONS

QUESTION 1: 10 minutes *(Taken from DoE Additional Exemplar P1 2008)*

The sketch below shows a stationary ambulance. The siren of the ambulance emits sound waves of frequency 700 Hz.
The driver of a car approaching the ambulance and passing it at constant speed, observes the frequency of the emitted sound waves to change by 80 Hz.

Stationary ambulance

Car passing at constant speed

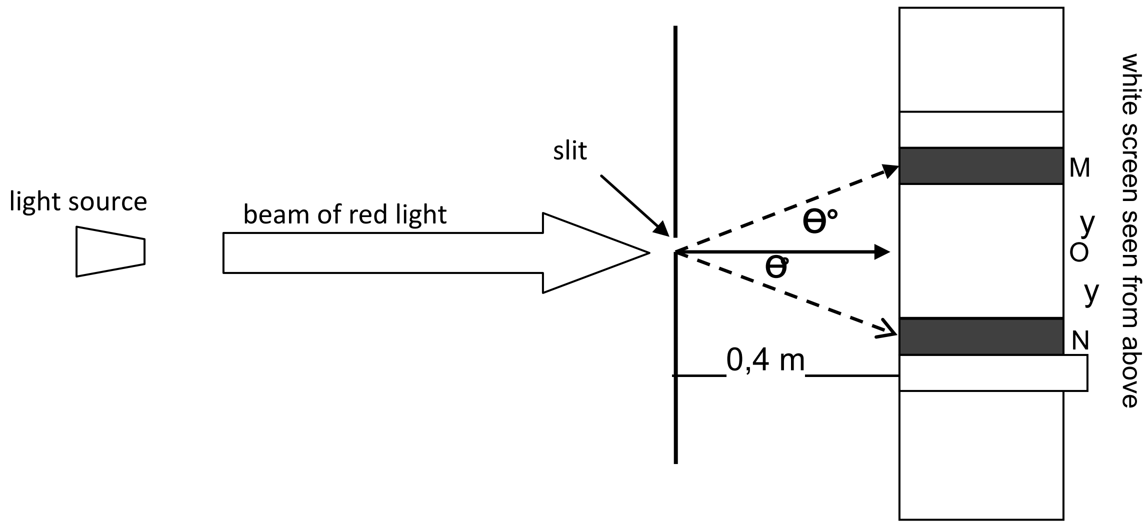
1.1 Name and state the wave phenomenon illustrated above. (3)

1.2 Take the speed of sound in air as 340 $m \cdot s^{-1}$ and calculate the speed at which the car passes the ambulance. (5)

[8]

QUESTION 2: 20 minutes *(Taken from DoE Additional Exemplar P1 2008)*

During a demonstration of a wave phenomenon, monochromatic red light passes through a slit of width $1,8 \times 10^{-4}$ m and shines on a flat screen a distance of 0,4 m away from the slit. The wavelength of the light is 675 nm.



2.1 Name the phenomenon demonstrated above. (1)

2.2 Briefly explain how the dark bands in the observed pattern are formed. (2)

2.3 Calculate the width 2*y* of the central bright band. (6)

2.4 How will your answer to QUESTION 2.3 change if the width of the slit is changed to 1,8 x 10^{-6} m? Write only INCREASES, DECREASES or REMAINS THE SAME. Give a reason for your choice. (3)
[12]

QUESTION 3: 10 minutes *(Taken from the DoE NSC Nov 2010 Paper 1)*

The siren of a burglar alarm system has a frequency of 960 Hz. During a patrol, a security officer, travelling in his car, hears the siren of the alarm of a house and approaches the house at constant velocity. A detector in his car registers the frequency of the sound as 1 000 Hz.

3.1 Name the phenomenon that explains the change in the observed frequency. (1)

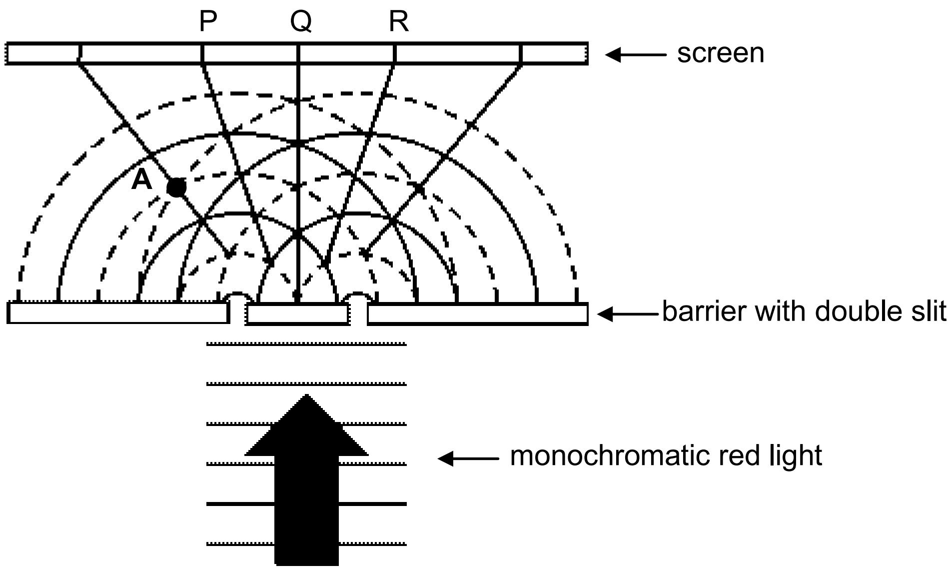
3.2 Calculate the speed at which the patrol car approaches the house. Use the speed of sound in air as 340 $m \cdot s^{-1}$. (4)

3.3 If the patrol car had approached the house at a higher speed, how would the detected frequency have compared to the first observed frequency of 1 000 Hz? Write down only HIGHER THAN, LOWER THAN or EQUAL TO. (1)
[6]

QUESTION 4: **10 minutes** *(Taken from the DoE NSC Nov 2010 Paper 1)*

Monochromatic red light passes through a double slit, as shown in the diagram below. Circular wave fronts, advancing towards the screen, are shown between the slits and the screen as dotted lines and solid lines. The solid lines represent crests and the dotted lines troughs.

Interference of the circular wave fronts results in an interference pattern observed on the screen. **P**, **Q** and **R** represent the centres of different bands in the interference pattern.



4.1 Define the term *interference*. (2)

4.2 What type of interference takes place at point **A**? Give a reason for the answer. (2)

4.3 Is band **P** a dark band or a red band? Refer to the type of interference involved to explain how you arrived at the answer. (3)

[7]

SECTION B: SOLUTIONS AND HINTS TO SECTION A

QUESTION 1

1.1 Doppler effect✓

A change in observed frequency (pitch) due to relative motion between observer and sound source. ✓✓

OR

A change in observed frequency (pitch) because the sound source and observer have different velocities with respect to the medium. ✓✓ (3)

1.2

$$f_L = \frac{v \pm v_L}{v \pm v_S} \cdot f_S \quad ✓$$

When the car approaches $f_L = \frac{340+v_L}{340} \times 700$✓

When the car moves away $f_L = \frac{340-v_L}{340} \times 700$✓

$$\frac{340+v_L}{340} \times 700 - \frac{340-v_L}{340} \times 700 = 80 \quad ✓$$

$v_L = 19{,}43\ m{\cdot}s^{-1}$ ✓ (5)

[8]

QUESTION 2

2.1 Diffraction (1)

2.2 Wavelets originating from different points in the slit reach the screen out of phase and interfere destructively on the screen. (2)

2.3

$\sin\theta = \frac{m\lambda}{a}$ ✓

$\sin □° = \frac{(1)675\times10^{-9}}{1{,}8 \times 10-4}$ ✓

✓ = 0,21 ° ✓

tan 0,21° = y/0,4✓

✓y = 1,47 x 10 $^{-3}$ m (1,47 mm) ✓

Width of central bright band

2y = 2(1,47 x 10 $^{-3}$) = 2,93 x 10 -3 m (2,93 mm) ✓ (6)

2.4 Increases✓

Diffraction is inversely proportional to the width of the slit. ✓✓

OR

Amount of diffraction is determined by the ratio λ/a. If *a* decreases, λ/ a will increase. ✓✓ (3)

[12]

QUESTION 3

3.1 Doppler effect ✓ (1)

3.2 $f_L = \frac{v \pm v_L}{v \pm v_s} f_s$

$\therefore\ 1\,000$ ✓ $= \frac{340 + v_L}{340}(960)$ ✓

$\therefore\ v_L = 14{,}17\ m{\cdot}s^{-1}$ ✓ (4)

3.3 Higher than ✓ (1)

[6]

QUESTION 4

4.1 When two waves pass through the same region of space at the same time✓, resulting in the superposition of waves / net amplitude / net energy. ✓

OR

Two waves meet /cross / interact / overlap / collide ✓

resulting in the superposition / reinforcement /cancellation / net amplitude / net energy of the waves. ✓ (2)

4.2 Constructive (interference)✓

The waves crossing each other are in phase. ✓/ Two troughs meet./

The path difference is an integer number of λ. (2)

4.3 Dark band ✓

It lies on the line combining all the points where crests and troughs overlap ✓ resulting in destructive interference. ✓

OR

It lies on the (nodal) line✓ where destructive interference occurs. ✓ (3)

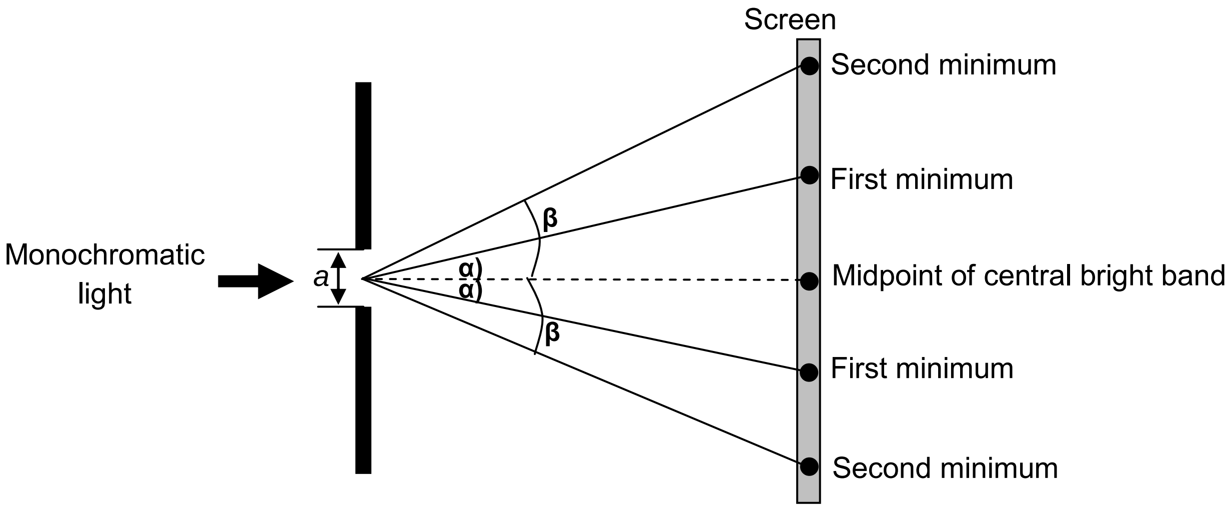
[7]

SECTION C: HOMEWORK

QUESTION 1: **15 minutes** *(Taken from the DoE NSC Nov 2010 Paper 1)*

The relationship between the degree of diffraction of light and slit width is investigated.

Monochromatic light of wavelength 410 nm is passed through a single slit at a *fixed distance* from a screen. The angles at which the first minimum (α) and the second minimum (β) occur are measured.



The experiment is repeated using the same light source but a slit of different width.

The results obtained from the two experiments are represented in the table below

	ANGLE OF 1ST MINIMUM (α)	ANGLE OF 2ND MINIMUM (β)
Slit 1	10°	20°
Slit 2	5°	10°

1.1 Define the term *diffraction*. (2)

1.2 For this investigation, name the following:

1.2.1 Dependent variable (1)

1.2.2 Independent variable (1)

1.3 Which ONE of **Slit 1** or **Slit 2** is the narrower slit? Explain the answer. (2)

1.4 Use the data in the table to calculate the width of **Slit 2**. (4)

[10]

QUESTION 2: 5 minutes

Huygens' Principle is used to explain the wave phenomena, interference and diffraction.

2.1 State Huygens' Principle. (2)

2.2 Use Huygens' Principle to explain the diffraction of water waves in a ripple tank as they pass through a narrow opening in a barrier. (3)

[5]

SECTION D: SOLUTIONS TO HOMEWORK

QUESTION 1

1.1 The ability of a wave to bend / spread out (in wave fronts)✓ as they pass through a (small) aperture / opening OR around a (sharp) edge/ points /corners / barrier. ✓ (2)

1.2 1.2.1 Angle of / (Degree of) diffraction ✓ (1)

1.2.2 (Slit) width ✓ (1)

1.3 (Slit) 1 ✓

Slit 1 represents the most diffraction. ✓

OR

Diffraction /Angle / sin θ / θ is inversely proportional to slit width. ✓

OR

$\sin\theta \ \alpha \frac{1}{a}$ or $\theta \ \alpha \frac{1}{a}$ ✓

OR

Larger angle at which first minimum for slit 1 is obtained. ✓

OR

Smaller angle at which first minimum for slit 2 is obtained.✓

(2)

1.4

$\sin\theta = \frac{m\lambda}{a}$ ✓

✓ ✓

$\sin 5° = \frac{(1)(410 \times 10^{-9})}{a}$

$\therefore$ a = 4,70 x 10^{-6} m ✓ (0,0000047 m / 4,7 μm)

(4)

[10]

QUESTION 2

2.1 Every point on a wave front acts as a source of secondary wavelets ✓that spread out in all directions ✓with the same speed and the same frequency as the wave. (2)

2.2 As the wave passes through the slit, the slit acts as a source for secondary wavelets, ✓which moves out in all directions, ✓ including the area behind the slit. ✓ (3)

[5]

SESSION 15

TOPIC: CONSOLIDATION EXERCISES ON ORGANIC MOLECULES AND THEIR REACTIONS

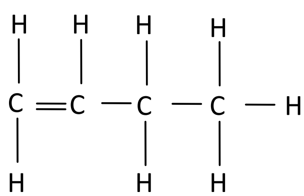
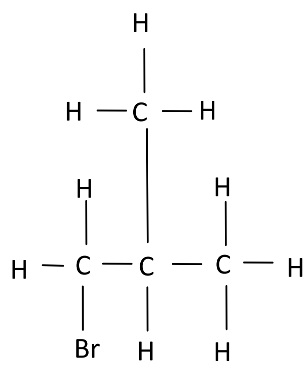
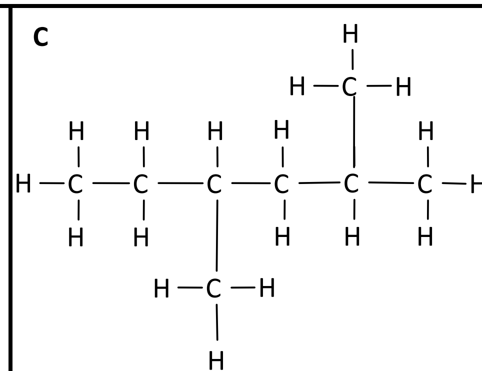
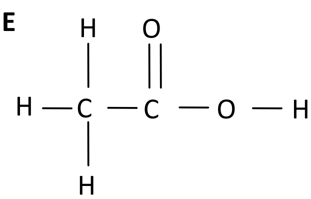
LESSON OVERVIEW

1. Typical exam questions: 55 minutes
2. Review/solutions/memo: 35 minutes

SECTION A: TYPICAL EXAM QUESTIONS

QUESTION 1: **17 minutes** *(Taken from the DoE NSC Nov 2010 Paper 2)*

The chemical properties of organic compounds are determined by their functional groups. The letters **A** to **F** in the table below represent six organic compounds

A 	**B** 	**C** 
D Methanal	**E** 	**F** Methyl methanoate

1.1 Write down the LETTER that represents the following:

1.1.1 An alkene (1)

1.1.2 An aldehyde (1)

1.2 Write down the IUPAC name of the following:

1.2.1 Compound **B** (2)

1.2.2 Compound **C** (2)

1.3 Write down the structural formula of compound **D**. (2)

1.4 Write down the IUPAC name of the carboxylic acid shown in the table. (2)

1.5 Write down the structural formula of compound **F**. (2)

[12]

QUESTION 2: **18 minutes** *(Taken from the DoE NSC Nov 2010 Paper 2)*

Five alcohols represented by the letters **A** – **E** are listed in the table below.

A	Methanol	**B**	Ethanol
C	Propan-1-ol	**D**	Butan-2-ol
E	2-methylpropan-2-ol		

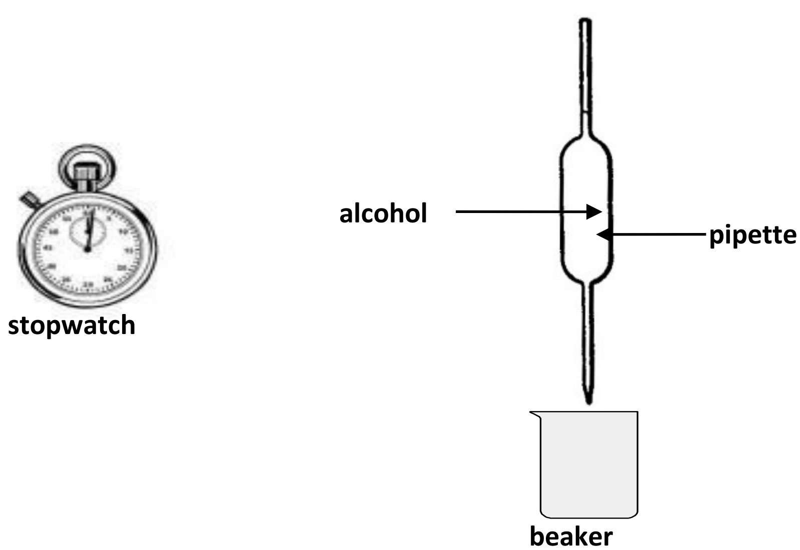
2.1 Which ONE of the above alcohols is a SECONDARY alcohol? Write down only the LETTER that represents the alcohol. (1)

2.2 The letter **E** represents 2-methylpropan-2-ol. For this alcohol, write down the following:

2.2.1 Its structural formula (2)

2.2.2 The LETTER in the table that represents one of its structural isomers (1)

2.3 Viscosity is a measure of a fluid's resistance to flow. Learners conduct an investigation to compare the viscosities of the first three alcohols (**A – C**) in the table above. They use the apparatus shown below.



The learners use the stopwatch to measure the time it takes a FIXED VOLUME of each of the alcohols to flow from the pipette. They record this flow time, which is an indication of the viscosity of each alcohol, as given in the table below.

	Alcohol	Flow time (s)
A	Methanol	4,0
B	Ethanol	7,9
C	Propan-1-ol	14,3

2.3.1 Formulate an investigative question for this investigation. (2)

2.3.2 Which ONE of the alcohols (**A**, **B**, or **C**) has the highest viscosity? Use the data in the table to give a reason for the answer. (2)

2.3.3 Refer to the intermolecular forces of the three alcohols (**A**, **B** and **C**) to explain the trend in viscosities as shown in the table. (2)

2.3.4 Lubricants reduce friction. Which one of alcohols, **A**, **B** or **C**, will be the best lubricant? (1)

2.4 Which ONE of 2-methylpropan-2-ol and butan-2-ol has the higher viscosity? (1)

2.5 Refer to intermolecular forces to explain the answer to QUESTION 2.4. (2)
[14]

QUESTION 3: **20 minutes** *(Taken from the DoE NSC Nov 2010 Paper 2)*

Prop-1-ene is a flammable alkene.

3.1 Why is prop-1-ene considered to be a dangerous compound? (1)

Through addition reactions, prop-1-ene can be converted to other compounds, such as alkanes and alcohols.

3.2 Which part of the structure of an alkene allows it to undergo addition reactions? (1)

3.3 In one type of addition reaction, prop-1-ene can be converted to an alcohol.

3.3.1 Use structural formulae to write a balanced equation for the formation of the alcohol during this addition reaction. (4)

3.3.2 Name the type of addition reaction that takes place. (1)

3.3.3 Write down the name or formula of the catalyst used in this reaction. (1)

3.4 Use molecular formulae to write down a balanced chemical equation for the complete combustion of propane. (3)

Prop-1-ene can be produced from an alcohol by an elimination reaction.

3.5 Use structural formulae to write a balanced chemical equation for the formation of prop-1-ene from a PRIMARY alcohol. (4)

3.6 Name the type of elimination reaction that takes place. (1)

[16]

SECTION B: SOLUTIONS AND HINTS TO SECTION A

QUESTION 1

1.1

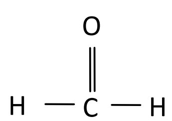
1.1.1 A ✓ (1)

1.1.2 D ✓ (1)

1.2.1 1-bromo-2-methylpropane ✓✓ (2)

1.2.2 2,4-dimethylhexane ✓✓ (2)

1.3

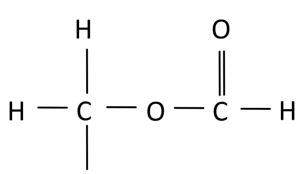


✓✓

(2)

1.4 Ethanoic acid ✓✓ (2)

1.5



✓✓

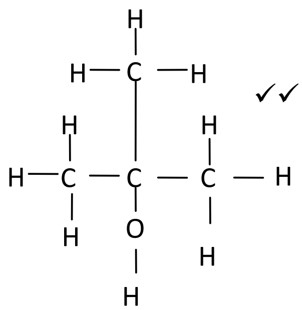
(2)

[12]

QUESTION 2

2.1 D ✓ (1)

2.2.1



(2)

2.2.2 D ✓ (1)

2.3 2.3.1

Criteria for investigative question	Mark
The dependent and independent variables are stated.	✓
Asks a question about the relationship between dependent and independent variables.	✓

Example:
What is the relationship between viscosity / flow time and chain length / number of C atoms / molecular mass / molecular size / molar mass / surface area / number of electrons / alcohols?
(or vice versa.)
How does /will the viscosity change when the chain length increases?
How are the viscosities of the alcohols related to their molar masses?
How does the viscosities of the first three alcohols compare?

(2)

2.3.2 C ✓
Longest flow time /flows the slowest / most resistance to flow ✓ (2)

2.3.3 Increase in chain length / molecular mass / molar mass / molecular size / surface area from A to C. ✓
Increase in (strength of) intermolecular / Van der Waals / dispersion / London / forces ✓ (2)

2.3.4 C ✓ (1)

2.4 D ✓ (1)

2.5 The more branched /more compact /more spherical alcohol / E has a smaller surface area (over which the intermolecular forces act). ✓ Decrease in (strength of) intermolecular forces / Van der Waals / dispersion / London /forces ✓ reduces resistance to flow (and thus lower viscosity). (2)

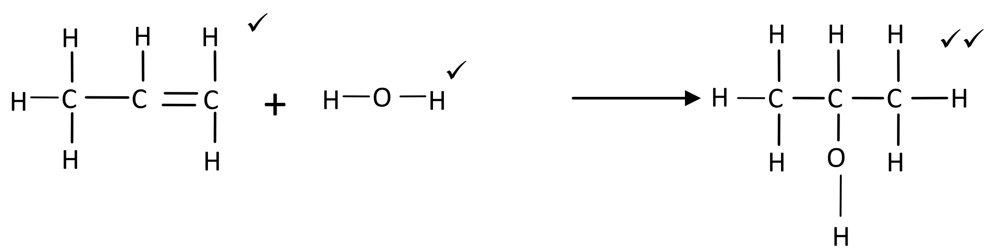
[14]

QUESTION 3

3.1 Prop-1-ene is (highly) flammable. ✓ (1)

3.2 Alkenes contain a <u>double</u> (carbon – carbon) / (C=C) / bond. ✓. (1)

3.3 3.3.1



(4)

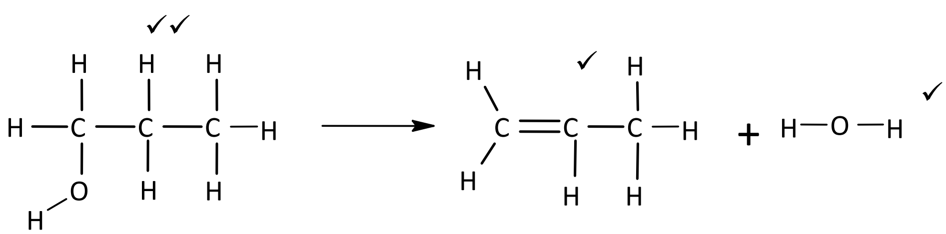
3.3.2 Hydration ✓ (1)

3.3.3 Sulphuric acid ✓ (1)

3.4 $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$

(reactants ✓ ; products✓ ; bal ✓) (3)

3.5



(4)

3.6 Dehydration ✓ (1)

[16]

SECTION C: HOMEWORK

QUESTION 1

Define the following terms::

1.1 structural isomer
1.2 general formula
1.3 homologous series
1.4 functional group [8]

QUESTION 2

Draw structural formulae for each of the following:

2.1 $CH_3 – (CH_2)_2 – CH(Cl)\text{-}CH_3$

2.2 $CH_3 – CH_2 – CH(CH_3)\ \ CHBr_2$ [4]

QUESTION 3

Study the following formulae:

A. CH_3COOH

B.
$$CH_3 — O — \overset{\overset{\displaystyle O}{\|}}{C} — H$$

C. $CH_3CH{=}CH_2$

D. CH_3CH_2OH

E. $CH_3 — CH_2 — CH_3$

From the above compounds listed write down only the letters representing:

3.1 TWO substances that react to form an ester.

3.2 TWO substances that can be structural isomers of each other.

3.3 ONE substances that is an unsaturated hydrocarbon.

3.4 ONE substance that is a saturated hydrocarbon. [8]

SECTION D: SOLUTIONS TO HOMEWORK

QUESTION 1

1.1 Structural isomers are organic molecules that have the same molecular formulae but different structural formulae. ✓✓

1.2 All members of a homologous series obey the same general formula ,i.e. they have the same number of carbon and hydrogen atoms if it is a hydrocarbon, e.g., alkanes have a general formula of C_nH_{2n+2}. ✓✓

1.3 All the organic molecules in a homologous series have the same functional group, and they obey the same general formula. ✓✓

1.4 A functional group is a bond or an atom or a group of atoms that all the members of the homologous series have in common. ✓✓ **[8]**

QUESTION 2

2.1

```
      H    H    H   Cl   H
      |    |    |    |    |
 H —  C —  C —  C —  C —  C — H
      |    |    |    |    |
      H    H    H    H    H
```

✓✓

2.2

```
      H    H    H    H
      |    |    |    |
 H —  C —  C —  C —  C — Br
      |    |    |    |
      H    H  H-C-H   Br
                |
                H
```

✓✓

[4]

QUESTION 3

3.1 A and D ✓✓

3.2 A and B ✓✓

3.3 C ✓✓

3.4 E ✓✓ **[8]**

SESSION 13

TOPIC: CONSOLIDATION EXERCISES ON RATES, CHEMICAL EQUILIBRIUM AND ELECTROCHEMISTRY

SECTION A: TYPICAL EXAM QUESTIONS

QUESTION 1: 20 minutes

In order to investigate the rate at which a reaction proceeds, a learner places a beaker containing concentrated nitric acid on a sensitive balance. A few pieces of copper metal are dropped into the nitric acid. Mass readings of the beaker and its contents are recorded every 15 s, from the moment the copper metal is dropped into the acid until shortly after there is no more copper metal present.

The mass readings taken during the investigation are given in the table below. The time at which the copper is dropped into the acid is recorded as 0 seconds.

Time (s)	Mass of beaker and contents (g)	Decrease in mass (g)
0	114,6	0
15	113,0	0,6
30	111,6	2,2
45	110,4	4,2
60	109,4	5,2
75	108,7	5,9
90	108,4	6,2
105	108,3	6,3
120	108,3	6,3
135	108,3	6,3
150	108,3	6,3

1.1 Which of the two physical quantities, time or mass, is the independent variable in this investigation. Explain your answer. (3)

1.2. Using the readings given in the table, plot a graph on this page of *decrease mass* versus *time*.

(7)

1.3. From the gradient of the graph it can be seen that the rate of the reaction change with time. Explain why the following changes in rate occur.

1.3.1 Reaction rate increases between 0 and 30s. (2)

1.3.2 Reaction rate decreases between 45 and 105s. (2)

1.3.3 After 105 s the rate becomes zero. (2)

1.4 State two ways in which the rate of this reaction could be increased. (4)

[20]

QUESTION 2: 20 minutes

A small quantity of cobalt chloride powder is dissolved in ethanol resulting in a blue solution. When a few drops of water are carefully added to the blue solution the colour changes to pink. The following equilibrium has been established:

$$CoCl_4^{2-}(aq) + 6H_2O(l) \rightleftharpoons Co(H_2O)_6^{2+}(aq) + 4Cl^-(aq)$$

blue pink

To investigate the factors which affect this equilibrium, the following experiments were performed:

Experiment 1: A small quantity of concentrated HCl is added to the solution. 2.1 Observation:…………………………………… (1)

Experiment 2: The test tube with the solution is cooled by immersing it in ice water. 2.2 Observation:…………………………………… (1)

Experiment 3: A few drops of silver nitrate are added to the solution. 2.3 Observation:……………………………………………….. (2)

2.4 Tabulate your observations: (3)

2.5 Name the effect that is illustrated in experiment 1. (1)

2.6 Was the forward or reverse reaction favoured as a result of the addition of the concentrated HCl? (1)

2.7 Use your observation in experiment 2 to state whether the forward reaction is exothermic or endothermic. (1)

2.8 Make use of Le Chatelier's principle to justify your answer in 2.7. (4)

2.9 In experiment 3, a white precipitate is formed when the silver nitrate is added.

2.9.1 Give the name of the white solid. (1)

2.9.2 Give the balanced chemical equation to explain the formation of the white precipitate. (3)

2.9.3 Explain how the addition of the silver nitrate affected the equilibrium. (3)

[21]

QUESTION 3: 15 minutes

Two half-cells, Pb^{2+}/Pb and O_2/H_20, in an acid solution are used to set up an electrochemical cell. The cell operates under standard conditions.

3.1 Give the standard conditions that apply to this electrochemical cell. (4)

3.2 Which half-cell represents the anode? (2)

3.3 Give the equation for the oxidation half-reaction. (2)

3.4 Give the equation for the reduction half-reaction. (2)

3.5 Give the balanced equation for the net reaction. (2)

3.6 Calculate the emf of the cell. (4)

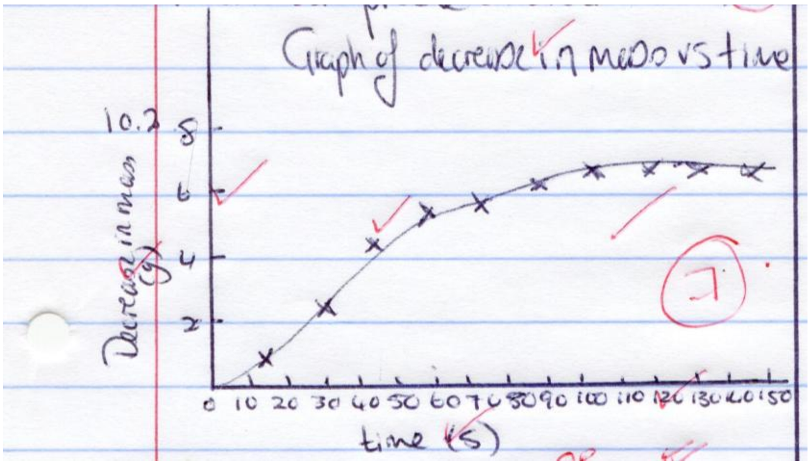
[16]

SECTION B: SOLUTIONS AND HINTS TO SECTION A

QUESTION 1

1.1 Time. √ It was decided to measure mass at predetermined times. √√ (3)

1.2



(7)

1.3.1 Cu and HNO_3 reacting together initially and rate is quick√√ (2)

1.3.2 HNO_3 concentration and Cu surface area decreasing√√ (2)

1.3.3 reaction has reached completion. √√ (2)

1.4. heated, √√copper surface area increased, √√ concentration of nitric acid increased √√ **(Any two)** (4)

[20]

QUESTION 2

2.1 Clear pink solution turns blue√ (1)

2.2 Clear blue solution turns pink√ (1)

2.3 Clear blue solution turns opaque pink solution (pink with white ppt) √√ (2)

2.4.

Equilibrium disturbance	Observation
Addition of HCl	Pink to blue√
Cooling of solution	Blue to pink√
Addition of AgNO3	Blue to opaque pink√

(3)

2.5. Common ion effect √ (1)

2.6. Reverse reaction √ (1)

2.7. Exothermic √ (1)

2.8. The decrease in temperature favours the exothermic reaction√. The solution Went from blue to pink √→ forward reaction favoured. √ So forward reaction is exothermic√. (4)

2.9.1. Silver chloride √ (1)

2.9.2. Ag+ (aq)√+ Cl- (aq)√→ AgCl (s)√ (3)

2.9.3. Silver nitrate reacts with Cl- ions thus removing them from the solution. √The concentration of chloride ions decreases so the equilibrium shifts so as to accommodate that change. The forward reaction is thus favoured√. and the solution turns pink. √. (3)

[21]

QUESTION 3

3.1 Concentration of Pb^{2+}(1M) √; H^+(1M) √; pressure of O_2 1 atm√; Temperature 25°C√ (4)

3.2 Pb√√ (2)

3.3 $2Pb\ (s) \rightarrow 2Pb^{2+}\ (aq) + 4e^-$√√ (2)

3.4 $O_2 + 4H^+ + 4e^- \rightarrow 2\ H_2O$√√ (2)

3.5 $2Pb + O_2 + 4H^+ \rightarrow 2\ H_2O + 2Pb^{2+}$√√ (2)

3.6 $E^\theta_{cell} = E^\theta_{cathode} - E^\theta_{anode}$ √

$= 1,23$ √ $- (-0,13)$√

$E^\theta_{cell} = 1,36\ V$ √ (4)

[16]

SECTION C: HOMEWORK

QUESTION 1: 15 minutes

A si!ver-nickel voltaic cell is made under standard conditions.

1.1 Give the reduction half-reaction. (2)

1.2 Write the half-reaction that occurs at the anode. (2)

1.3 Which electrode increases in mass when the cell is used? (2)

1.4 Give the cell notation for this cell. (3)

1.5 What is the emf of this cell? (4)

[13]

QUESTION 2: 16 minutes

2.1 Lowering the temperature of an equilibrium reaction will:

A decrease the rate of the forward reaction only.
B decrease the rate of the reverse reaction only.
C decrease the rate of both the forward and reverse reactions.
D have no effect on the rate of reaction.

2.2 Assuming equilibrium is reached in the reaction:

$2CO(g) \quad O_2(g) \rightleftharpoons 2CO_2(g)$; $\Delta H = -565kJ$

A greater yield of carbon dioxide can be obtained by …

A raising the temperature and pressure.
B raising the temperature and lowering the pressure.
C lowering the temperature and pressure.
D lowering the temperature and raising the pressure.

2.3 Carbon, carbon dioxide and carbon monoxide are in equilibrium in a container of which the volume can change. The balanced equation for the equilibrium reaction is as follows:

$C(s) + CO_2(g) \rightleftharpoons 2CO(g)$

While the temperature is kept constant, the volume of the container is decreased and a new equilibrium is established. Which one of the following statements regarding the number of moles of CO and the concentration of CO at the new equilibrium condition is correct?

	Number of moles of CO	[CO]
A	the same	greater
B	Less	greater
C	Less	less
D	More	the same

2.4 A saturated solution of NaCl in water is prepared at 60°C. The equation for this solubility equilibrium is:

$NaCl(s) \rightleftharpoons Na^+(aq) + Cl^-(aq) \qquad \Delta H > 0$

Which one of the following changes will cause more $NaCl_{(s)}$ to form?

A add H_2O.
B add a catalyst.
C increase temperature.
D decrease temperature.

2.5 Two substances, A and B, are in equilibrium with their product, AB, at a temperature of 10°C as indicated by the following equation:

$A(g) + B(g) \rightleftharpoons AB(g) \qquad \Delta H > 0$

At 10°C the rate of the forward reaction is equal to x $mol\cdot s^{-1}$.

The temperature is then increased. Which statement regarding the forward and reverse reaction rates is correct at the higher temperature?

	Forward rate	Reverse rate
A	equal to x	equal to x
B	less than x	less than x
C	greater than x	greater than x
D	less than x	greater than x

2.6. When an amount of sulphur and oxygen are sealed in a container at 700K, an equilibrium is established according to the following equation:

$S(s) + O_2(g) \leftrightarrows SO_2(g) \qquad \triangle H < 0$

If the pressure is increased, while the temperature of 700K is maintained, the:

A value of K_c increase
B volume of the gases increase
C amount of SO_2 decreases
D amount of O_2 remains the same.

2.7. The following equilibrium exists in a saturated salt solution.

$NaCl(s) \leftrightarrows Na^+(aq) + Cl^-(aq)$

What can be done in order to obtain a precipitate of NaCl ?

A Increase the pressure on the system
B Heat the solution
C Add concentrated Hydrochloric acid (HCl)
D Bubble chlorine (Cl_2) through the solution.

2.8. In which of the following reactions will a *decrease* in pressure cause the yield of the product(s) to *increase*?

A $2\,SO_{2(g)} + O_{2(g)} \leftrightarrows 2SO_{3(g)}$

B $2\,H_2O_{(g)} \leftrightarrows 2H_{2\,(g)} + O_{2(g)}$

C $2\,NO_{2(g)} \leftrightarrows N_2O_{4(g)}$

D $2\,HI_{(g)} \leftrightarrows H_{2\,(g)} + I_{2\,(g)}$

2.9. Consider the following system which is in equilibrium:

$$4HCl\,(g) + O_2(g) \leftrightarrows 2Cl_2(g) + 2H_2O(l) \quad (\triangle H < 0)$$

The yield of chlorine gas can best be *increased* by the following combination of changes in temperature and pressure:

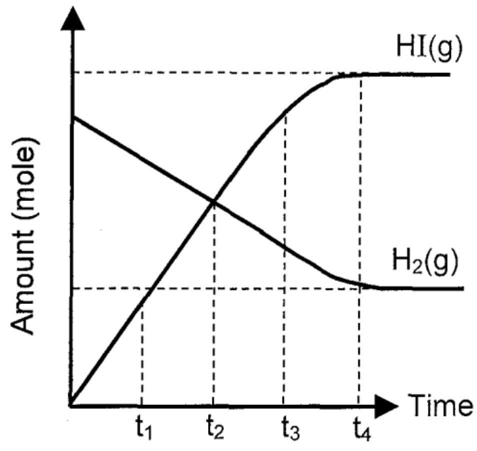
	Temperature	Pressure
A	Increase	Decrease
B	decrease	Decrease
C	decrease	Increase
D	increase	Increase

2.10. The following reversible reaction is used in the production of hydrogen iodide gas:

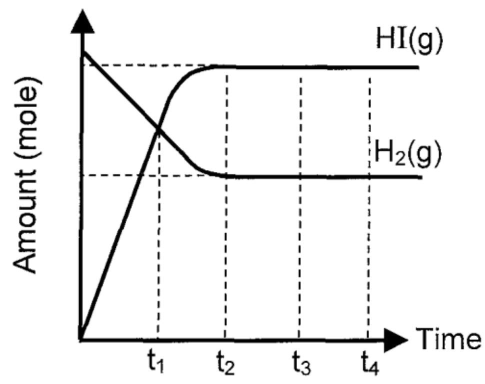
$$H_2\,(g) + I_2\,(g) \rightleftharpoons 2HI\,(g) \qquad \Delta H < 0$$

The graph X of amount of reagents against time was obtained when the reaction was carried out under certain conditions.

The graph Y was obtained for the same experiment using the same amount of H_2 (g), but certain changes were made to the conditions affecting the system.



GRAPH X



GRAPH Y

2.11 Which one of the following sets of changes could have been introduced to the system to obtain graph Y?

A More $I_{2(g)}$ was added and the temperature was decreased.
B The temperature and pressure was decreased.
C A catalyst was added and the temperature was increased.
D A catalyst was added and the temperature was decreased.

2.12. Assuming equilibrium is reached in the reaction:

$$2CO(g) + O_2(g) \rightleftharpoons 2CO_2(g) \qquad \Delta H = -565 \text{ kJ}$$

A greater yield of carbon dioxide can be obtained by:

A raising the temperature and pressure.
B raising the temperature and lowering the pressure.
C lowering the temperature and the pressure.
D lowering the temperature and raising the pressure.

2.13. Consider the following equilibrium reaction:

$$2N_2(g) + O_2(g) \rightleftharpoons 2N_2O(g) \qquad \Delta H = 160 \text{ kJ·mol}^{-1}$$

Which ONE of the following changes gives the greatest increase in the equilibrium yield of N_2O?

	TEMPERATURE	PRESSURE
A	Decrease	Increase
B	Decrease	Decrease
C	Increase	Increase
D	Increase	Decrease

(13 x 2) [26]

SECTION D: SOLUTIONS TO HOMEWORK

QUESTION 1

1.1 silver√√ (2)

1.2 $Ni (s) \rightarrow Ni^{2+} (aq) + 2e^-$ √√ (2)

1.3 silver√√ (2)

1.4 $Ni(s)/Ni^{2+}(aq)$, 1 $mol \cdot dm^{-3}$ // $Ag^+ (aq)$, 1 $mol \cdot dm^{-3}$ /Ag

√ √ √ (3)

1.5 $E^\theta_{cell} = E^\theta_{cathode} - E^\theta_{anode}$ √

$= 0,80$ √ $- (-0,25)$√

$E^\theta_{cell} = 1,05$ V √ (4)

[13]

QUESTION 2

2.1 C
2.2 D
2.3 B
2.4 D
2.5 C
2.6 D
2.7 C
2.8 B
2.9 C
2.10 C
2.11 B
2.12 C
2.13 A (13 x 2) **[26]**

SESSION 14

TOPIC 1: ELECTROSTATICS - GRADE 11 REVISION

SECTION A: TYPICAL EXAM QUESTIONS

QUESTION 1: 10 minutes

(Taken from the DoE Physical Sciences Feb-March Paper 1 2010)

Capacitors are circuit devices used to store electrical energy. The capacitance of capacitors depends, amongst other factors, on the plate area. The larger the plate area, the more the energy that can be stored.

1.1 Apart from plate area, state TWO other factors that can influence the capacitance of a capacitor. (2)

1.2 A certain parallel plate capacitor consists of two plates, each having dimensions of 2cm by 10cm. The plates are 0,2mm apart and are held at a potential difference of 20V. The space between the plates is filled with air.

1.2.1 Sketch the electric field pattern between the two oppositely charged parallel plates of the capacitor. (3)

1.2.2 Calculate the capacitance of this capacitor. (5)

[10]

QUESTION 2: 30 minutes

(Taken from the GDE Preliminary Examination September 2009 Paper 1)

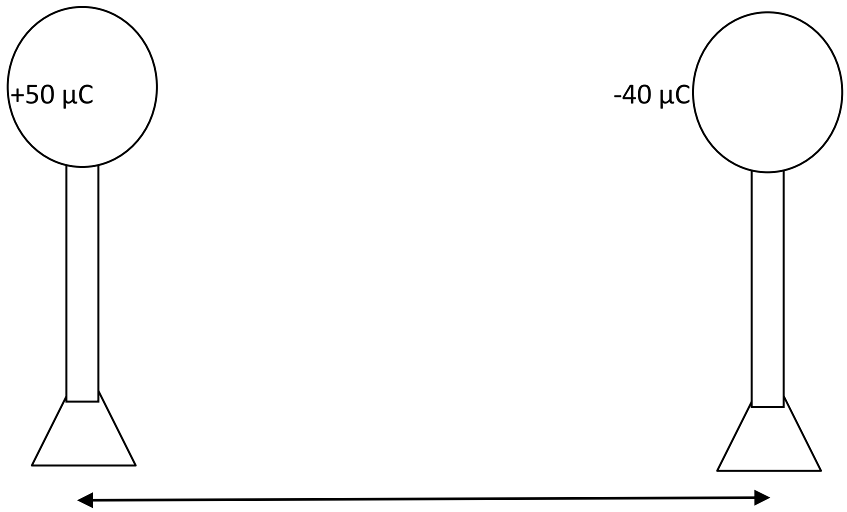
2.1 Capacitors are widely used in common household electrical appliances like television screens, computers, alarm systems etc.

2.1.1 What is the function of a capacitor in an electrical appliance. (2)

2.1.2 A specific capacitor stores a maximum of 30 nC of charge at a potential difference of 12 V across the ends. Calculate the capacitance of this capacitor. (3)

2.1.3 During an electrical thunderstorm the potential difference between the earth and the bottom of the clouds can be 35 000 kV. If the surface area of the clouds is 1×10^8 m^2 at a height of 1 200 m above the surface of the earth, calculate the capacitance of this gigantic "earth-cloud" capacitor. Take the permittivity of air to be the same as the permittivity of a vacuum. (4)

2.2 Two point charges with magnitudes of +50 μC and -40 μC respectively, are placed at a distance of 450 mm from each other on isolated stands as shown in the diagram below. The charges are allowed to touch each other and are then placed back at their original positions.



2.2.1 Calculate the magnitude and nature of each of the charges after they have touched each other, and have been moved back to their original positions. (2)

2.2.2 Draw a sketch of the electric field pattern which results after the two charges have touched each other. (4)

2.2.3 Determine the magnitude and direction of the force which the charges exert on each other after touching each other. (4)

2.2.4 The original force which existed between the two charges before touching each other was 80 times greater than the final force between the two charges after touching. Explain why? (3)

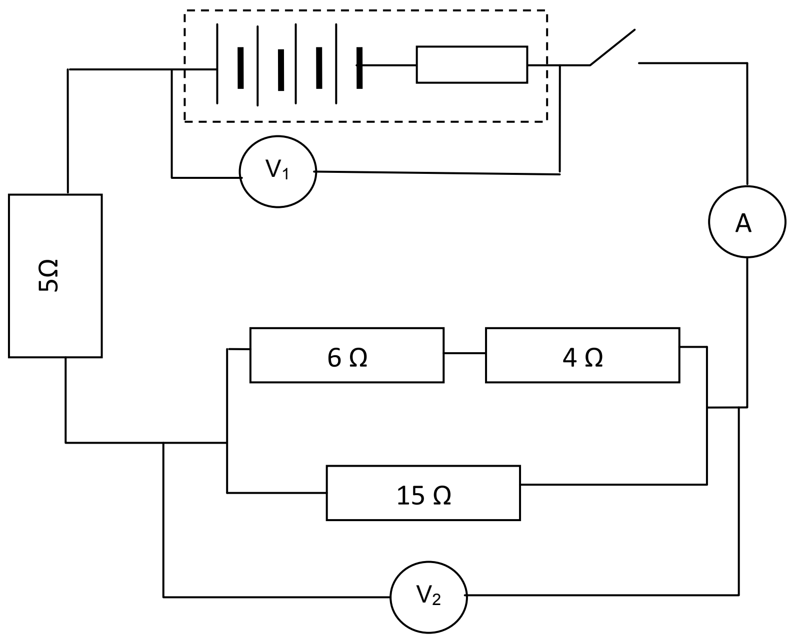
[22]

TOPIC 2: ELECTRICITY - GRADE 11 REVISION

QUESTION 3: 25 minutes

(Taken from the GDE Preliminary Examination September 2009 Paper 1)

3.1 The circuit on the following page shows a battery consisting of four 1.5 V cells connected in series. An ammeter with negligible resistance is connected in series to the battery. The reading on the ammeter is 0.5 A when the switch is closed. The connectors have negligible resistance and the voltmeters have very high resistance. Voltmeter V_1 has a reading of 5.5 V when the switch is closed.



3.1.1 Calculate the value of the internal resistance of a single cell. (4)

3.1.2 Calculate the value of the resistance of the external circuit. (4)

3.1.3 Calculate the value of the reading on voltmeter V_2 (4)

3.2

3.2.1 A small submersible element takes a certain time to boil a single cup of water. If a similar element of lower resistance, plugged into the same plug, is also used to boil a single cup of water, it takes a shorter time. Explain, using electricity concepts (current, voltage, work done, heat and power), why the water boils <u>faster</u> when the resistance of the element is <u>decreased</u>. (3)

3.2.2 Two learners, namely Bongani and David, want to design an investigation to prove the assumption made in 3.2.1.

3.2.2.1 Design a method that they will be able to use. List the most important steps – at least five steps – that they need to carry out in order to end up with reliable results. Ensure that you mention in your steps at least one safety precaution that Bongani and David have to take. (3)

3.2.2.2 List the controlled variables, the dependant variable and independent variable that Bongani and David have to consider to ensure that the results to their investigation is valid. (2)

[20]

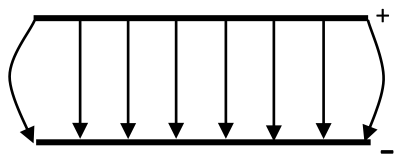
SECTION B: SOLUTIONS AND HINTS TO SECTION A

TOPIC 1

QUESTION 1

1.1 Dielectric ✓
Distance between plates ✓ (2)

1.2.1



Checklist	Mark
Evenly spaced field lines.	✓
Direction of field lines from positive to negative.	✓
Field lines curved at the ends.	✓

(3)

1.2.2

$$C = \frac{\varepsilon_0 A}{d} \checkmark = \frac{(8{,}85\times10^{-12})\overset{\checkmark}{(}2\times10^{-2})\overset{\checkmark}{(}10\times10^{-2})}{0{,}2\times10^{-3}\ \checkmark}$$

$= 8{,}85 \times 10^{-11}$ F ✓ (5)

[10]

QUESTION 2

2.1.1 It stores electrical charge **OR** electric potential energy ✓✓ (2)

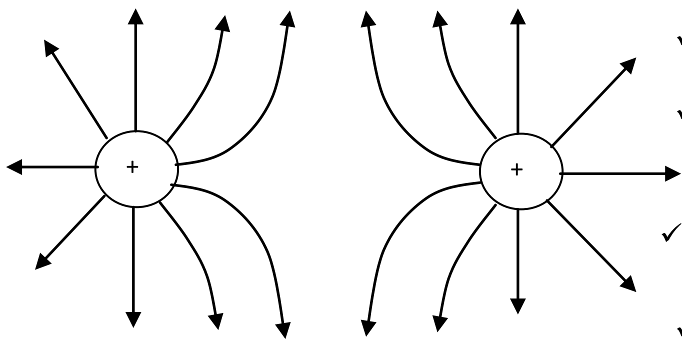
2.1.2 $C = \overset{\checkmark}{\frac{Q}{V}} = \frac{30\times10^{-9}}{12}\checkmark = 2.5\times10^{-9}F(=2.5nF)\checkmark$

(3)

2.1.3 $C = \frac{\varepsilon_0 A}{d}\checkmark = \frac{(8.85\times10^{-12})(1\times10^{8})\checkmark}{1200\ \checkmark} = 1.06F \checkmark$ (4)

2.2.1 New charge = $\frac{(+50\mu C)+(-40\mu C)}{2} = +5\mu C$ ✓✓ (2)

2.2.2



✓direction of lines

✓shape of lines on outside

✓ shape of lines on inside

✓symmetry of lines

(4)

2.2.3 $F = \frac{kQ^2}{r^2} = \frac{(9\times10^9)(5\times10^{-6})^2}{(0.45)^2} = 1.11\text{N}$ ✓ ✓ ✓ repulsion ✓ (4)

2.2.4 Charges of +50 μC and -40 μC became smaller by factors of 10 and 8 respectively. As F α Q_1Q_2 ✓, it means that the ✓original force was 10 x 8 = 80 larger than the final force. ✓ (3)

[22]

TOPIC 2

QUESTION 3

3.1.1

$$r_{battery} = \frac{V_{used in battery}}{I_{total}} = \frac{0.5}{0.5} = 1\Omega$$ ✓ ✓ thus each cell = 1Ω/4 = 0.25Ω ✓ ✓ (4)

3.1.2 $\frac{1}{R_p} = \frac{1}{6+4} + \frac{1}{15} = \frac{1}{6}$ ✓ so R_p = 6Ω ✓ and

$R_{external} = r_1 + r_2 = 5 + 6 = 11\ \Omega$ ✓ ✓

OR

$$R_{external} = \frac{V_{external}}{I_{total}} = \frac{5.5}{0.5} = 11\Omega$$ ✓ ✓ ✓ ✓ (4)

3.1.3

$V_{5\Omega} = IR = 0.5(5) = 2.5V$ ✓✓ thus

$V_2 = 5.5 - 2.5 = 3$ V ✓ ✓

OR

$V_2 = I_{total}R_p = 0.5(6) = 3V$ ✓✓✓ ✓ (4)

3.2.1 $W = \frac{V^2 t}{R}$ The <u>same potential difference</u> is applied so that V stays constant. The same amount of water is boiled so the energy W stays the same. This means that <u>R α t</u>. It means that if the resistance decreases ✓ then <u>the time to boil the water decreases and the water boils faster.</u> ✓

OR

$P = \frac{V^2}{R}$ The <u>same potential difference</u> ✓ is applied so that V stays constant. This means that <u>P α !/R</u>. ✓ If R decreases then P increases and the <u>time taken to boil the water is less</u>. ✓ (3)

3.2.2.1

- Measure identical amounts of water, and place in identical containers at identical temperatures.
- Place the first submersible element into one of the containers, taking care that there are no open wires in contact with water
- Start the current and the stopwatch at the same time
- Note the time it takes to boil the water.
- Make sure that you handle the hot container with suitable tongs or gloves.
- Place the second element into the second container of water
- Start the current and the stopwatch at the same time
- Note the time it takes to boil the water.
- Compare the times

✓	Identical amounts of water, Initial temperature the same
✓	Name one safety measure
✓	Measure the time to boil

(3)

3.2.2.2 Controlled variables:

- Amount of water
- Same initial temperature
- Same voltage eg plug into 220 V
- Same type of container to control the heating area as well as the conduction of heat.
- Water needs to reach boiling point

Independent variable: The type of element

Dependant variable: Time it takes to boil the water

Any two ✓ ✓

(2)

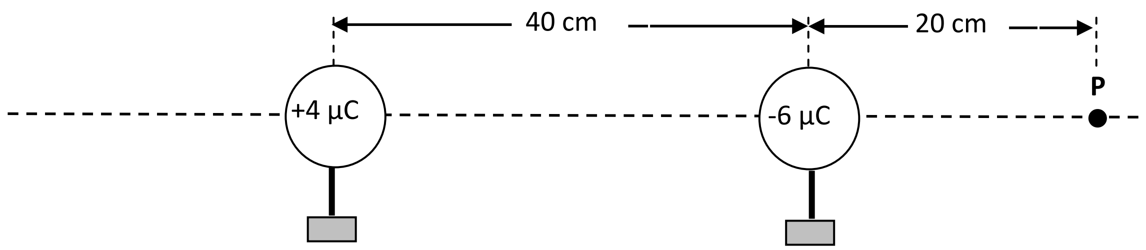
[20]

SECTION C: HOMEWORK

TOPIC 1

QUESTION 1: 15 minutes
(Taken from the DoE Physical Sciences November Paper 1 2009)

Two metal spheres on insulated stands carry charges of +4 μC and -6 μC respectively. The spheres are arranged with their centres 40 cm apart, as shown below.



1.1 Calculate the magnitude of the force exerted by each sphere on the other. (4)

1.2 By what factor will the magnitude of the force in QUESTION 10.1 change if the distance between the spheres is halved? (Do not calculate the new value of the force.) (1)

1.3 Calculate the net electric field at point P as shown in the diagram above. (6)

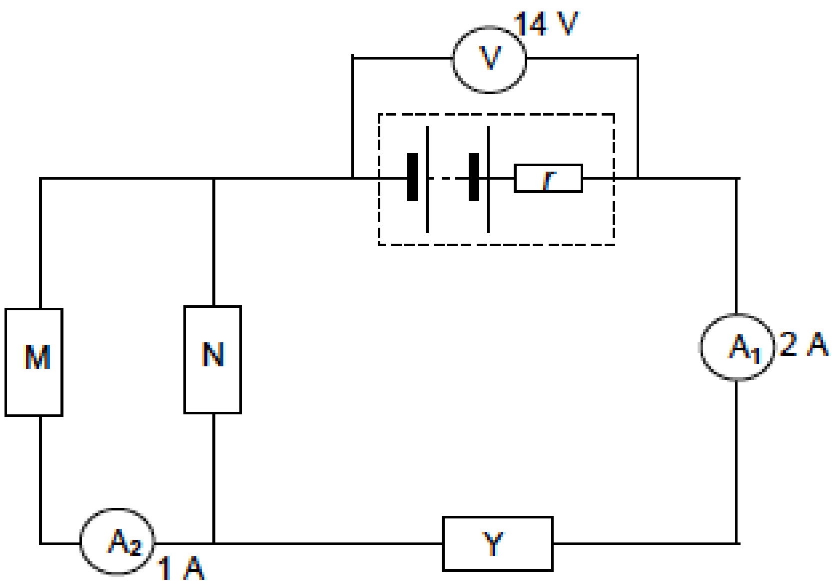
1.4 The spheres are now brought into contact with each other and then returned to their original positions. Now calculate the potential energy of the system of two charges. (5)

[16]

TOPIC 2:

QUESTION 2: 15 minutes *(DoE Physical Sciences Feb – March Paper 1 2010)*

The circuit diagram below shows a battery with an internal resistance *r,* connected to three resistors, M, N na Y. The resistance of N is 2Ω and the reading on voltmeter V is 14V. The reading on ammeter A_1 is 2A, and the reading on ammeter A_2 is 1A. (The resistance of the ammeters and the connecting wires may be ignored.)



2.1 State Ohm's law in words. (2)

2.2 How does the resistance of M compare with that of N? Explain how you arrived at the answer. (2)

2.3 If the emf of the battery is 17V, calculate the internal resistance of the battery. (5)

2.4 Calculate the potential difference across resistor N. (3)

2.5 Calculate the resistance of Y. (4)

[16]

SECTION D: SOLUTIONS TO HOMEWORK

QUESTION 1

1.1 $$F = \frac{kQ_1Q_2}{r^2} \checkmark = \frac{(9\times10^9)(4\times10^{-6})(6x10^{-6})\checkmark}{(0.4)^2 \checkmark} = 1.35\,\text{N} \checkmark$$

(4)

1.2 Four ✓ (1)

1.3 E (6μC) = kQ/r² ✓ ✓

= $(9 \times 10^9)(6 \times 10^{-6})/(0.,2)^2$ ✓ ✓

= $1,35 \times 10^6$ N·C^{-1} to the left.

E (4μC) = kQ/r²

= $(9 \times 10^9)(4 \times 10^{-6})/(0.,6)^2$ ✓ ✓

= 1×10^6 N·C^{-1} to the right.

Take to the right as positive:

E_{net} = $-1,35 \times 10^6 + 1 \times 10^5$ = $-1,25 \times 10^6$ N·C^{-1}

= $1,25 \times 10^6$ N·C^{-1} to the left ✓ (6)

1.4 New charge = $(+4x10\text{-}^6) + (-6x10^{-6})/2 = -1 \times 10^{-6}$ C ✓

U = kQ_1Q_2/r ✓

= $(9 \times 10^9)(-1 \times 10^{-6})^2$ ✓/0,4 ✓

= $2,25 \times 10^{-2}$ J ✓ (5)

[16]

QUESTION 2

2.1 The current through a conductor is directly proportional to the potential difference across its ends at constant temperature. ✓✓ (2)

2.2 Equal ✓

2 A divides equally at T (and since $I_M = 1$ A it follows that $I_N = 1$ A) ✓

OR

$I \propto \frac{1}{R}$, $\therefore R_M = R_N$ (2)

2.3 emf = IR + Ir ✓ $\therefore$ 17 = 14 + Ir ✓ $\therefore$ Ir = 3 V

$r = \frac{V_{lost}}{I}$ ✓ $= \frac{3}{2}$ ✓ $= 1{,}5\ \Omega$ ✓ (5)

2.4 $V_N = IR_N$ ✓ = (1)(2) ✓ = 2 V ✓ (3)

2.5 $V_Y = 14 - 2 = 12$ V ✓

$V_Y = IR_Y$ ✓ $\therefore$ $12 = (2)R_Y$ ✓

$\therefore$ $R_Y = 6\ \Omega$ ✓ (4)

[16]

SESSION 15

TOPIC: ELECTRODYNAMICS - MOTORS AND GENERATORS AND ALTERNATING CURRENT

SECTION A: TYPICAL EXAM QUESTIONS

QUESTION 1: 13 minutes

(Taken from the DoE Physical Sciences Preparatory Examination Paper 1 2008)

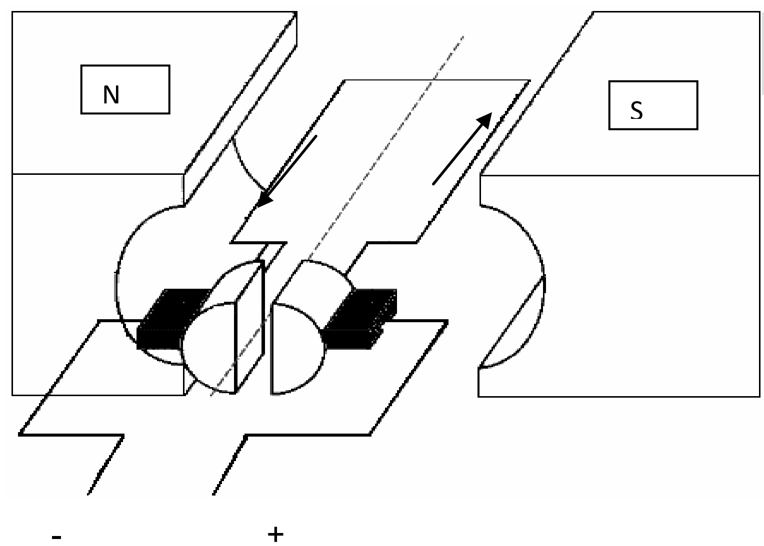
Electric motors are important components of many modern electrical appliances. AC motors are used in washing machines and vacuum cleaners, and DC motors are used in toys and tools.

1.1 What energy conversion takes place in electric motors? (2)

1.2 What is the essential difference in the design between DC and AC motors? (2)

1.3 List THREE ways in which the efficiency of the motor can be improved. (3)

1.4 Consider the diagram below. The conventional current flows in the direction indicated by the arrows.



● position A

1.4.1 In which direction (clockwise or anti-clockwise), as seen from position A, will the coiled armature rotate if the switch is closed? (1)

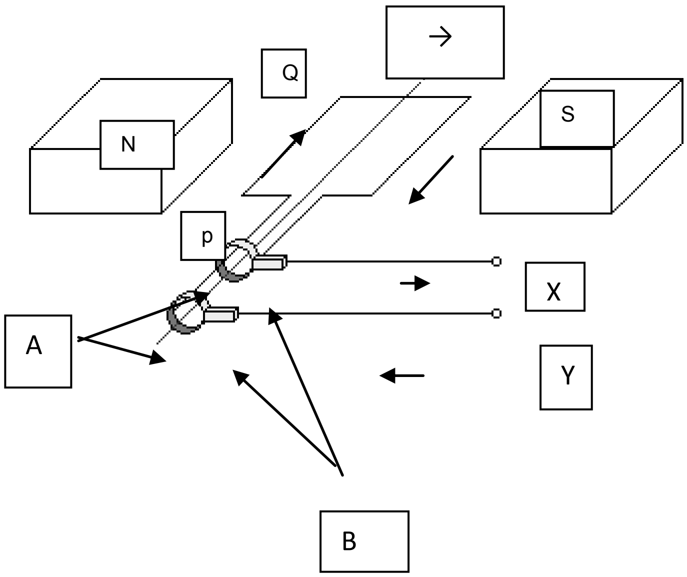
1.4.2 Why does the armature continue moving in the same direction once it has reached the vertical position? (2)

[10]

QUESTION 2: 10 minutes

(Taken from the DoE Physical Sciences Exemplar Paper 1 2008)

The simplified sketch below shows the principle of operation of the alternating current (AC) generator.



2.1 Name the parts labelled A and B respectively. (2)

2.2 In which direction does segment PQ of the coil have to be rotated in order to cause the current direction as shown in the diagram? Write down only clockwise or anticlockwise. (1)

2.3 Write down TWO changes that can be brought about to improve the output of the generator. (2)

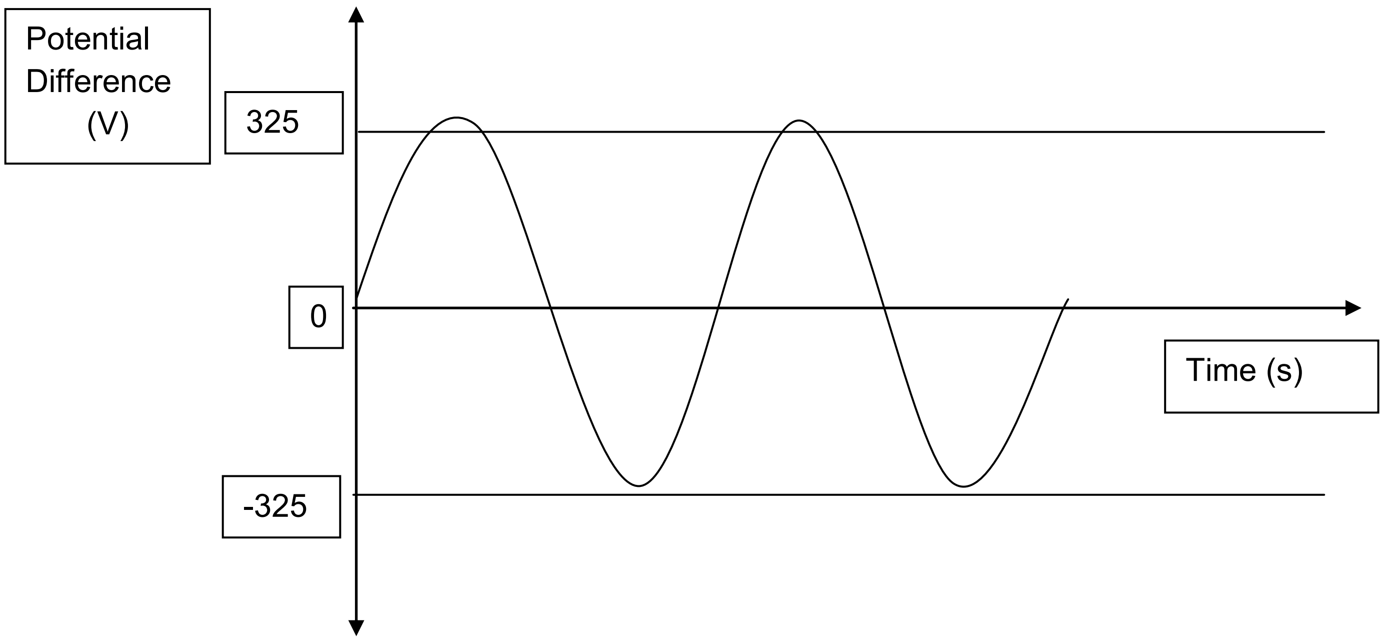
2.4 What changes must be made to the AC generator to make it function as a DC motor? (2)

[7]

QUESTION 3: 10 minutes

(Taken from the DoE Physical Sciences Preparatory Examination Paper 1 2008)

The waveform on the following page is a graphical representation of the variation of voltage (V) versus time (t) for an alternating current.

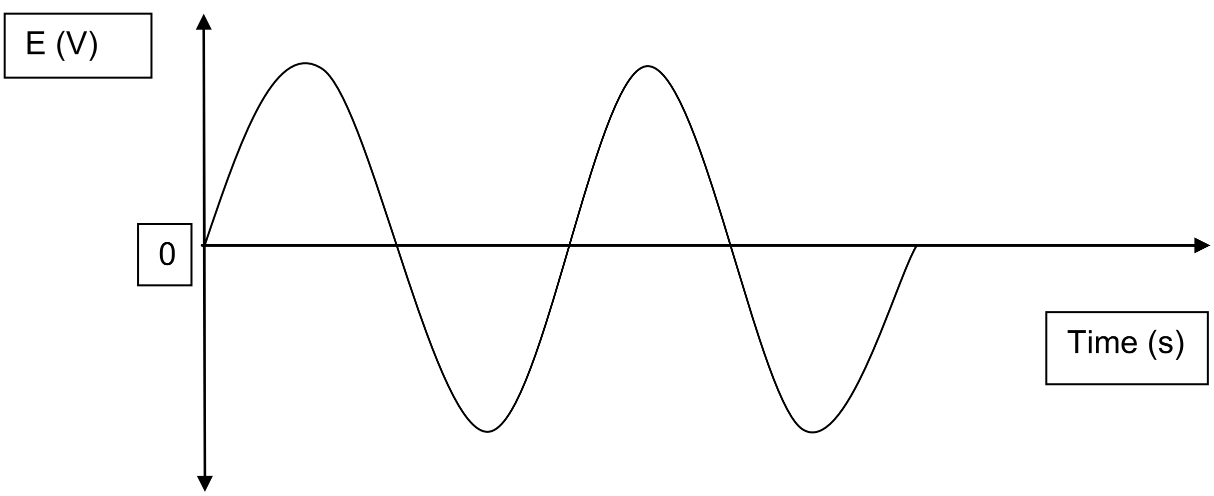


3.1 Explain the advantage of using alternating current at power stations. (2)

3.2 Calculate the average power dissipated by this generator if the rms current produced is 13A. (5)
[7]

QUESTION 4: 7 minutes
(Taken from the DoE Physical Sciences Exemplar Paper 1 2008)

The induced emf versus time graph for an AC generator is shown below:



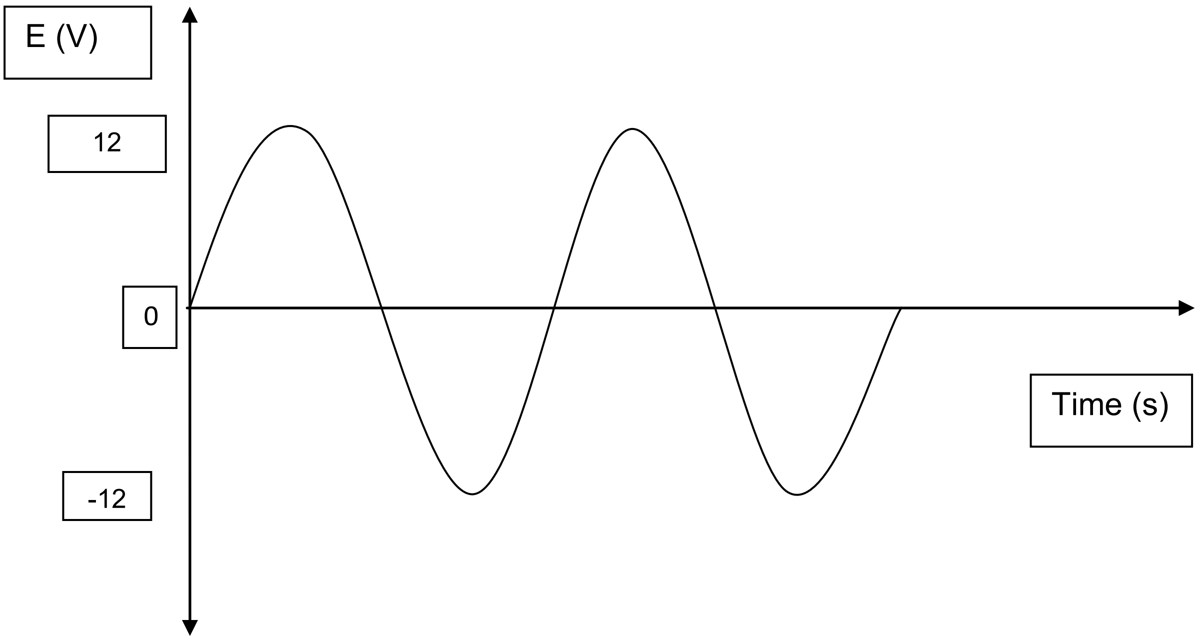
4.1 Sketch a graph to show how the above waveform changes, if at all, after changing this generator into a DC generator. (2)

4.2 State TWO advantages of using AC over DC for the long-distance transmission of electrical power. (2)
[4]

QUESTION 5: 15 minutes

(Taken from the DoE Physical Sciences Additional Exemplar Paper 1 2008)

The average power of a lamp is 15W. This lamp can be used with either an AC supply or a DC supply. The graph below shows the AC potential difference.



5.1 Calculate the potential difference of a DC supply that will produce the same brightness of the lamp. (3)

5.2 Calculate the peak current through the lamp when connected to a 12V AC supply. (4)

5.3 Draw a sketch graph of current through the lamp against time when connected to the AC supply. Indicate the value of the peak current on the graph. (3)
[10]

SECTION B: SOLUTIONS AND HINTS TO SECTION A

QUESTION 1

1.1 Electrical energy √ converted to rotational mechanical energy. √ (2)

1.2. A DC motor reverses current direction with the aid of the commutator whenever the coil is in the vertical √ position to ensure continuous rotation.

An AC motor, with alternating current as input, works without commutators since the current alternates.√ (2)

1.3 Increase the number of turns on each coil/increased number of coils √
Stronger magnets √
Bigger current √ (3)

1.4.1 Clockwise √ (1)

1.4.2 Its own momentum, √ split ring commutator changes direction √ of current, every time the coil reaches the vertical position. (2)

[10]

QUESTION 2

2.1 A = slip rings √
B = brushes √ (2)

2.2 anti-clockwise √ (1)

2.3 Any two:
Increase the number of turns of the coil √
Increase the magnetic field strength (stronger magnets) √
Increase speed of rotation
Use horse-shoe magnet –***(it helps to concentrate the field)*** (2)

2.5 Use split ring commutators instead of slip rings. √
Add a battery to provide electrical energy to drive motor. √ (2)

[7]

QUESTION 3

3.1 The voltage can be altered by using transformers. √ Transformers only operate on AC current. Electrical energy can be transmitted over long distances at low current √, and experience low energy loss. (2)

3.2. $V_{RMS} = V_{max} / \sqrt{2}$ √

$= 325/\sqrt{2}$ √

$= 0,707\ (325) = 230\ V$

$P_{ave} = V_{RMS}\, I_{RMS}$ √

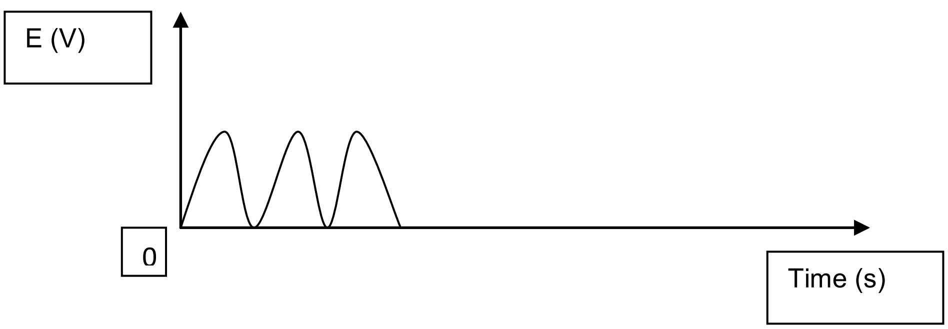
$= 230 \times 13$ √

$= 2990W$ √ (5)

[7]

QUESTION 4

4.1 Correct shape √ √



(2)

4.2 **Any two:**

Easier to generate and transmit from place to place √
Easier to convert from AC to DC than the reverse √
Voltage can be easily changed by stepping it up or down
High frequency used in AC make it more suitable for electric motors (2)

[4]

QUESTION 5

5.1 $V_{RMS} = V_{max} / \sqrt{2}$ √

$= 12/\sqrt{2}$ √

$= 8{,}49$ V √ (3)

5.2 $P_{ave} = V_{RMS} I_{RMS}$ √

$15 = 8{,}49 \times I_{RMS}$ √

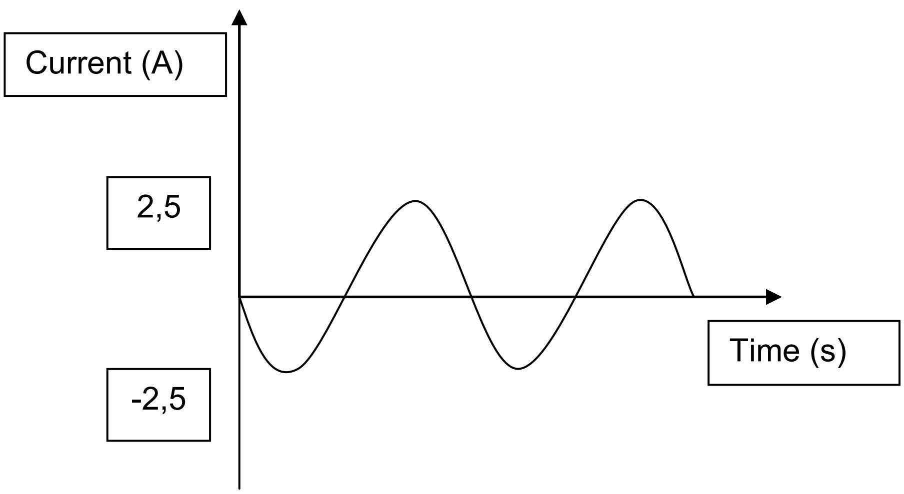
$I_{RMS} = 1{,}77$ A

$I_{RMS} = I_{max} / \sqrt{2}$

$I_{max} = 1{,}77\sqrt{2}$ √

$= 2{,}5$ A √ (4)

5.3



Checklist	Marks
Axes drawn and correctly labelled	√
Shape of graph as indicated	√
Peak current correctly indicated on y-axis	√

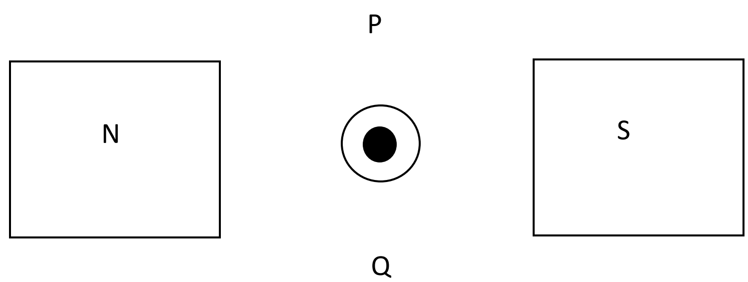
(3)
[10]

SECTION C: HOMEWORK

QUESTION 1: 7 minutes

1.1 Conventional current flows from:
A. North to South
B. South to North
C. Positive to negative
D. Negative to positive

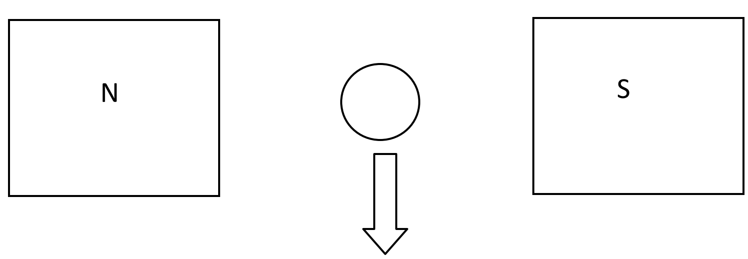
1.2 Referring to the below aerial sketch of a section of a motor, predict the direction of movement of the conducting wire.



A. Towards P
B. Towards Q
C. Into the page
D. Out of the page

1.3 Which of the following is not a function of the commutator?
A. Supplies electric current
B. Reverses the current each half turn.
C. Stops the current for a split second to allow the coil to rotate.
D. Converts the current into AC

1.4 Referring to the aerial sketch of a section of a dynamo below, predict the direction of conventional current in the conducting wire. The arrow represents the applied force.



A. Towards North
B. Towards South
C. Into the page
D. Out of the page

1.5 Which of the following energy conversion combinations is correct?

	Motor	Dynamo
A	Electrical to kinetic	Electrical to kinetic
B	Kinetic to electrical	Electrical to kinetic
C	Electrical to kinetic	Kinetic to electrical
D	Kinetic to electrical	Kinetic to electrical

(5 x 2) [10]

QUESTION 2: 13 minutes

2.1 What is the advantage of using more than one coil in the rotor of any motor? (2)

2.2 In any motor, what is the function of:

2.2.1 commutators? (1)

2.2.2 brushes? (1)

2.3 Can the speed of a motor be changed without making changes to the motor itself? Explain your answer. (2)

2.4 Explain the basic difference between a motor and a generator. (2)

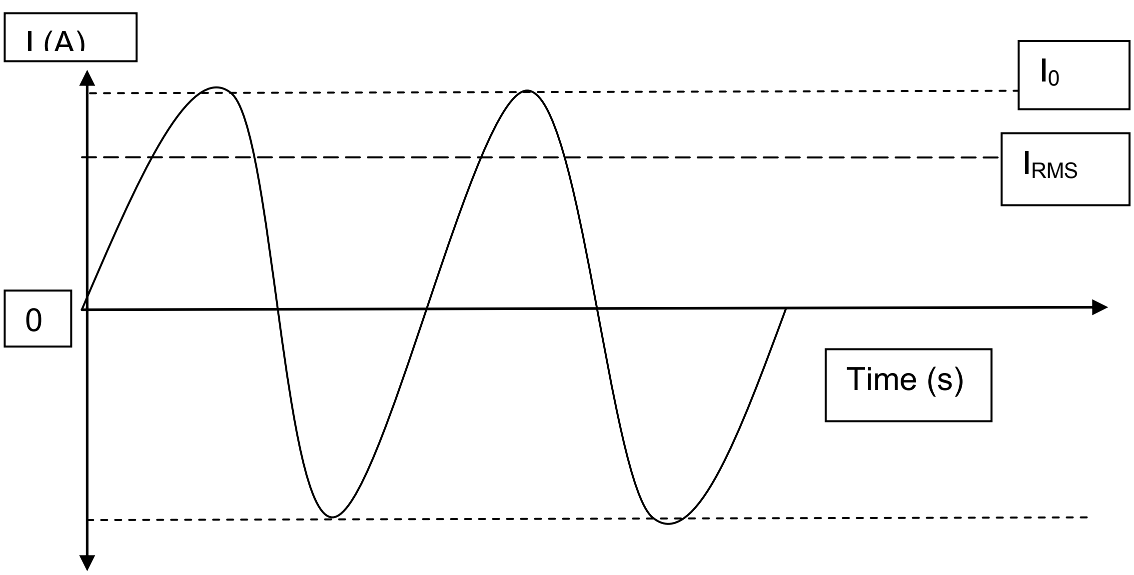
2.5 How does Faraday's Law apply to a generator? (2)

[10]

QUESTION 3: 10 minutes

(Taken from the DoE Physical Sciences Exemplar Paper 1 2008)

The sine wavefront shown below represents the variation of current (I) with time (t) for a generator used by a man to light his home. The current alternates between a maximum and a minimum.



In the diagram, I_0 = the peak current, I_{RMS} = root mean square current, $I_{AVERAGE}$ = average value of the current

3.1 Write down an expression for the instantaneous current in terms of the frequency of the source and the time. (2)

3.2 Write down a formula which represents the relationship between the maximum peak current (I_0) and the root mean square current (I_{RMS}). (2)

3.3 The frequency of the AC generated by ESKOM is 50Hz. A sub-station supplies 240V (RMS) to a house. Calculate the peak voltage at a wall socket. (3)

3.4 Explain why it is of greater value to use RMS current than the average. (2)
[9]

SECTION D: SOLUTIONS TO HOMEWORK

QUESTION 1

1.1 C
1.2 B
1.3 D
1.4 D
1.5 C

(5 x 2) **[10]**

QUESTION 2

2.1 There will be more current, more movement results. √ √ (2)

2.2.1 To stop the current briefly every 180º and to swop the directon of the current every 180º. √ (1)

2.2.2 To allow for free rotation of the coil. √ (1)

2.3 Yes. √ More current can be run through the coil. √ (Changing the number of coils or the strength of the magnets would be changing the actual structure of the motor.) (2)

2.4 A motor converts electrical energy into kinetic energy √ and a generator converts kinetic energy into electrical energy. √ In a motor the current needs to be provided and movement is created. In a generator the movement needs to be provided and a current is produced. (2)

2.5 More interaction of the magnetic field causes the conductor to have more current induced in it. √ So the faster the movement, the greater the current. √ (2)
[10]

QUESTION 3

3.1 $I = I_0 \sin\omega t$ √ √ or $I = I_0 \sin 2\pi f t$ (2)

3.2 $I_{RMS} = I_0 / \sqrt{2}$ √ √ (2)

3.3 $V_0 = \sqrt{2}\ V_{RMS}$ √ = 1,414 x 240 √ = 339,36V√ (3)

3.4 The average value of the current over the cycle is zero and no useful power is delivered. √ √ (2)
[9]