Please paste the barcoded label here	TOTAL MARKS

NATIONAL SENIOR CERTIFICATE EXAMINATION
NOVEMBER 2024

PHYSICAL SCIENCES: PAPER II

EXAMINATION NUMBER													

Time: 3 hours 200 marks

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This question paper consists of 28 pages as well as a Data Sheet of 3 pages (i–iii). Please make sure that your question paper is complete.
2. Read the questions carefully.
3. **Answer ALL the questions on the question paper and hand it in at the end of the examination. Remember to write your examination number in the space provided.**
4. Unless instructed otherwise, you do NOT have to give state symbols (phase indicators) when asked to write a balanced chemical equation.
5. Use the data and formulae whenever necessary.
6. Show all the necessary steps in calculations.
7. Where appropriate, take your answers to two decimal places.
8. It is in your own interest to write legibly and to present your work neatly.
9. One blank page (page 28) is included at the end of the examination paper. If you run out of space for an answer, use this page. Clearly indicate the number of your answer should you use this extra space.

FOR OFFICE USE ONLY: MARKER TO ENTER MARKS

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Total
Mark									
Marker's Initials									
Moderated Mark									
Moderator's Initials									
Question Total	**20**	**23**	**20**	**24**	**28**	**22**	**24**	**39**	**200**
Re-mark									
Initials									
Code									

IEB Copyright © 2024

QUESTION 1 MULTIPLE CHOICE

Every question has only one correct answer. You may use the space provided to solve the questions BUT YOU MUST INDICATE YOUR CHOSEN ANSWER FOR EACH QUESTION IN THE GRID BELOW. Make a clear cross (X) in the box corresponding to the letter that you consider to be correct.

A	B	C	D

Here the option C has been marked as an example.

1.1	**A**	**B**	**C**	**D**
1.2	**A**	**B**	**C**	**D**
1.3	**A**	**B**	**C**	**D**
1.4	**A**	**B**	**C**	**D**
1.5	**A**	**B**	**C**	**D**
1.6	**A**	**B**	**C**	**D**
1.7	**A**	**B**	**C**	**D**
1.8	**A**	**B**	**C**	**D**
1.9	**A**	**B**	**C**	**D**
1.10	**A**	**B**	**C**	**D**

1.1 Which one of the following is the correct formula of tin(IV) chlorate?

A $Ti_4C\ell O_3$
B $Ti(C\ell O_3)_2$
C $Sn(C\ell O_3)_2$
D $Sn(C\ell O_3)_4$

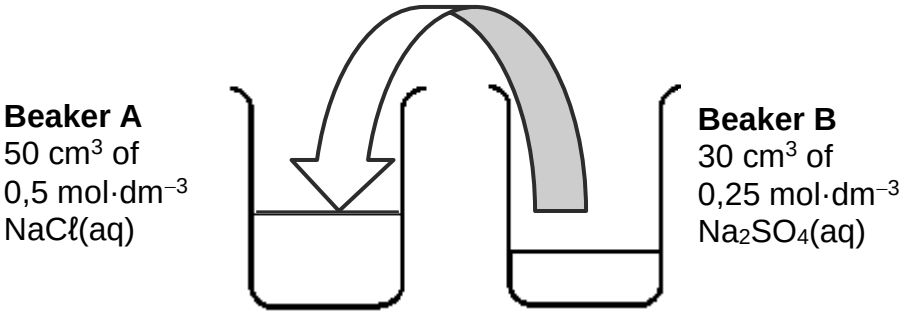
1.2 How many moles of FeS_2 are required to produce 32 g of $SO_2(g)$?

$$4FeS_2(s) + 11O_2(g) \rightarrow 2Fe_2O_3(s) + 8SO_2(g)$$

A 0,25
B 0,50
C 1,0
D 2,0

IEB Copyright © 2024

1.3 Beakers **A** and **B** contain aqueous solutions of two different sodium salts, the concentrations and volumes of which are indicated in the diagram. All of the solution in beaker **B** is poured into beaker **A**.



The new concentration of **sodium ions** in beaker **A** is given by …

A $\dfrac{0,025 + 0,0075}{0,050}$

B $\dfrac{0,025 + 0,015}{0,050}$

C $\dfrac{0,025 + 0,0075}{0,080}$

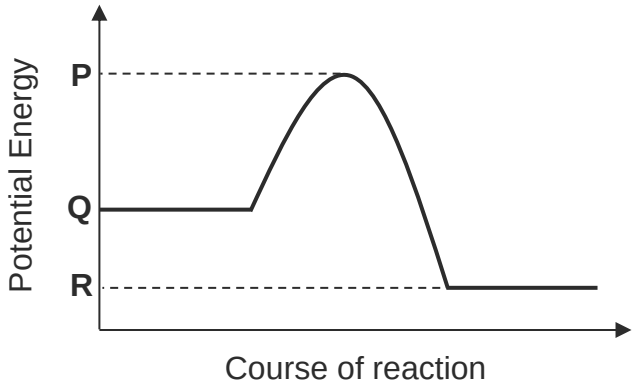
D $\dfrac{0,025 + 0,015}{0,080}$

1.4 Which one of the following gas samples will have the largest volume at STP?

A 48 g of oxygen
B 6 g of hydrogen
C 16 g of helium
D 28 g of nitrogen

IEB Copyright © 2024

1.5 Consider the energy profile graph for a reversible reaction shown below.



Which statement(s) is/are CORRECT?

I **P** represents the activation energy for the forward reaction.
II ΔH for the forward reaction is equal to **R–Q**.
III A catalyst lowers both **Q** and **R** equally and therefore does not affect ΔH.

A All are correct.
B None are correct.
C Only II is correct.
D Only II and III are correct.

1.6 $NaCH_3CO_2$ is a soluble salt. In a 1 mol·dm^{-3} solution of $NaCH_3CO_2$, the species that will be present in the greatest concentration will be ...

A Na^+
B OH^-
C $CH_3CO_2^-$
D CH_3CO_2H

1.7 A galvanic cell is set up using the following half-reactions and a suitable salt-bridge.

$$2H_2O + O_2 + 4e^- \rightleftharpoons 4OH^- \qquad E^\theta = +0{,}40\ V$$
$$Fe^{3+} + e^- \rightleftharpoons Fe^{2+} \qquad E^\theta = +0{,}77\ V$$

When this cell operates under standard conditions, the pH …

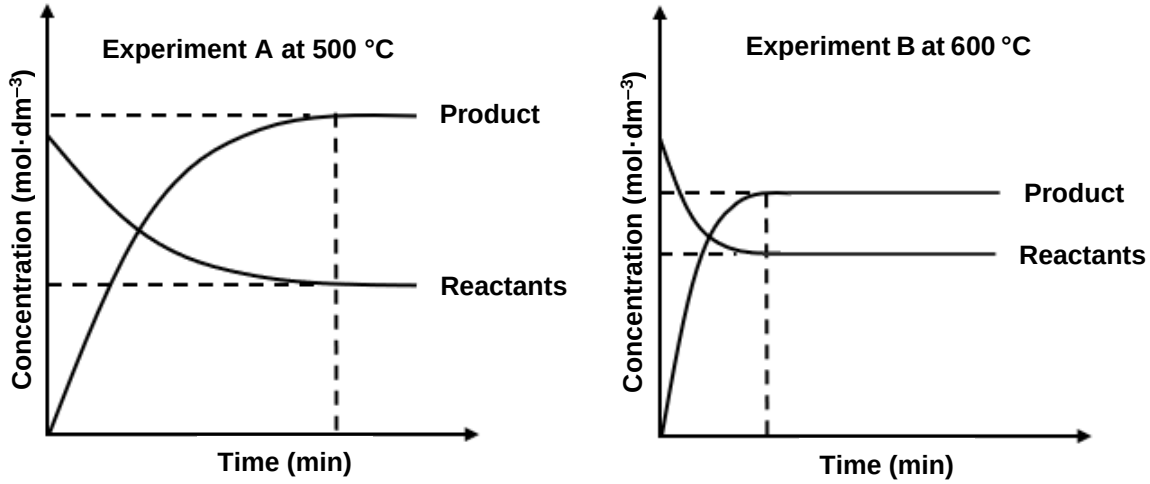
A at the anode will increase.
B at the anode will decrease.
C at the cathode will increase.
D at the cathode will decrease.

IEB Copyright © 2024

1.8 Two experiments were conducted using the reversible reaction shown below.

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$

An equal number of moles of H_2 and I_2 were added to the container each time before it was sealed. Experiment **A** was conducted at **500 °C** and Experiment **B** at **600 °C**. The graphs of concentration vs time for each experiment were plotted using the same scale.



Deduce whether the forward reaction is exothermic or endothermic and how the value of the equilibrium constant K_c differs for the two experiments.

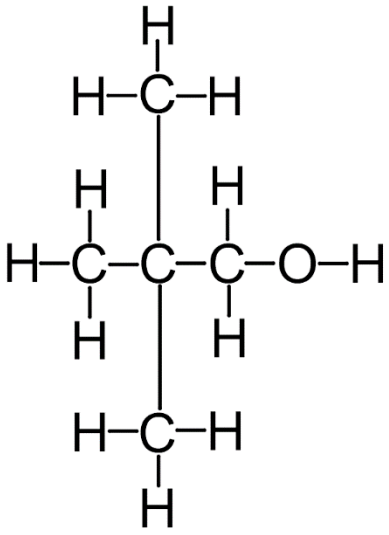
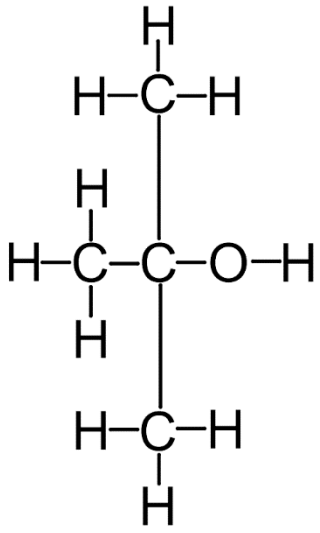
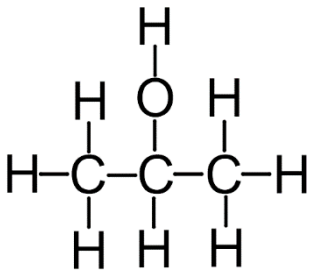
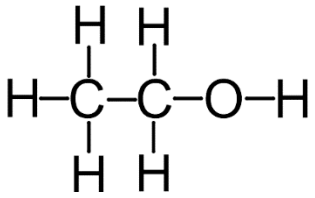
	The forward reaction is …	K_c in Experiment B is …
A	Exothermic	Greater
B	Exothermic	Less
C	Endothermic	Greater
D	Endothermic	Less

1.9 Which compound **does not have** the molecular formula $C_4H_8O_2$?

A methylpropanoic acid
B ethyl ethanoate
C butane-1,2-diol
D propyl methanoate

IEB Copyright © 2024

1.10 Which alcohol **cannot** be dehydrated?

A	B
	
C	D
	

[20]

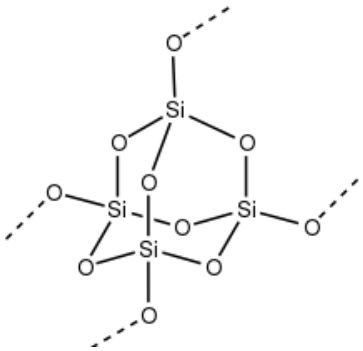
IEB Copyright © 2024

QUESTION 2

2.1 Silicon dioxide, SiO_2, reacts with HF or HCℓ to form water and $SiF_4(g)$ or $SiCℓ_4(ℓ)$ respectively.

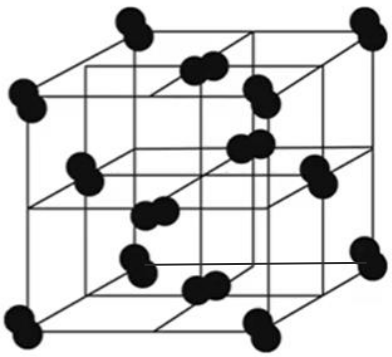
2.1.1 Write a balanced equation for the reaction between SiO_2 and HF. (2)

2.1.2 The structure of silicon dioxide is shown. Explain the extremely high melting point (1 713 °C) of silicon dioxide. (3)



2.1.3 Explain why SiF_4 is a gas at room temperature, while $SiCℓ_4$ is a liquid. (4)

2.2 The diagram shows the structure of solid fluorine.



2.2.1 Circle the correct word within the brackets. (1)

The particles represented by  in the lattice structure are (ATOMS / MOLECULES / IONS).

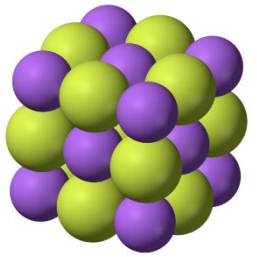
2.2.2 Name the predominant force or bond that keeps fluorine in the solid state. (1)

IEB Copyright © 2024

2.3 Fluorine reacts with …

- rhenium (Re) to form rhenium heptafluoride, a covalent compound with a melting point of 48 °C.
- sodium to form sodium fluoride, an ionic compound with a melting point of 993 °C.

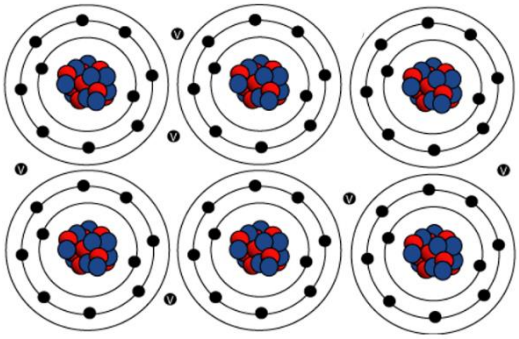
2.3.1 The diagrams represent three of the substances mentioned above. Identify the substances by writing the chemical **formula** of the element / compound in the space provided. (3)



(a)



(b)



(c)

2.3.2 Complete the sentences comparing the electron distribution in different substances: (3)

In covalent compounds, the bonding electrons are _____.

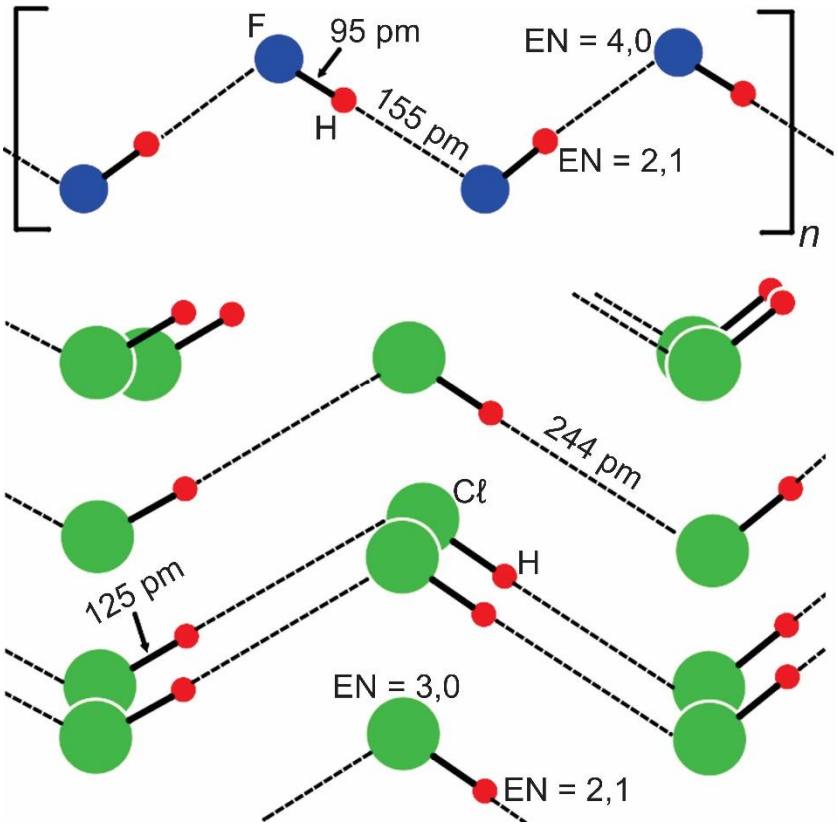
In ionic compounds, electrons are _____.

In metals, the electrons are _____.

IEB Copyright © 2024

2.4 The diagrams below show the crystal structure of HF(s) and HCℓ(s). In the diagrams, EN = electronegativity and pm = picometre (1 pm = 10^{-12} m).

HF(s) melts at a higher temperature than HCℓ(s).



2.4.1 Name the **predominant** type of intermolecular forces between … (2)

(a) HF molecules _____

(b) HCℓ molecules _____

2.4.2 Refer to the diagrams to explain two reasons why the forces between HF molecules are stronger than those between HCℓ molecules. (4)

_____

_____

_____

_____

_____

_____

_____

_____

[23]

IEB Copyright © 2024

QUESTION 3

The reaction of magnesium carbonate tablets with hydrochloric acid was used to investigate the effect of different factors on the rates of reactions. In each experiment the mass of the tablets was the same and equal volumes of acid were used.

3.1 Write a balanced chemical equation for the reaction between magnesium carbonate and hydrochloric acid. (3)

3.2 Describe an appropriate experimental method to measure the rate of this reaction. Include the appropriate measuring equipment and all quantities that should be measured to determine the rate. (3)

The results of five experiments are tabulated below.

Experiment	Concentration of acid ($mol \cdot dm^{-3}$)	Initial temperature (°C)	Time for reaction to end (s)	
			Whole tablet	Crushed tablet
1	1,0	23	46	
2	1,0	23		40
3	1,5	23	39	
4	2,0	30	31	
5	2,0	26	35	

[*Ref: Heyworth and Briggs, All About Chemistry O Level*]

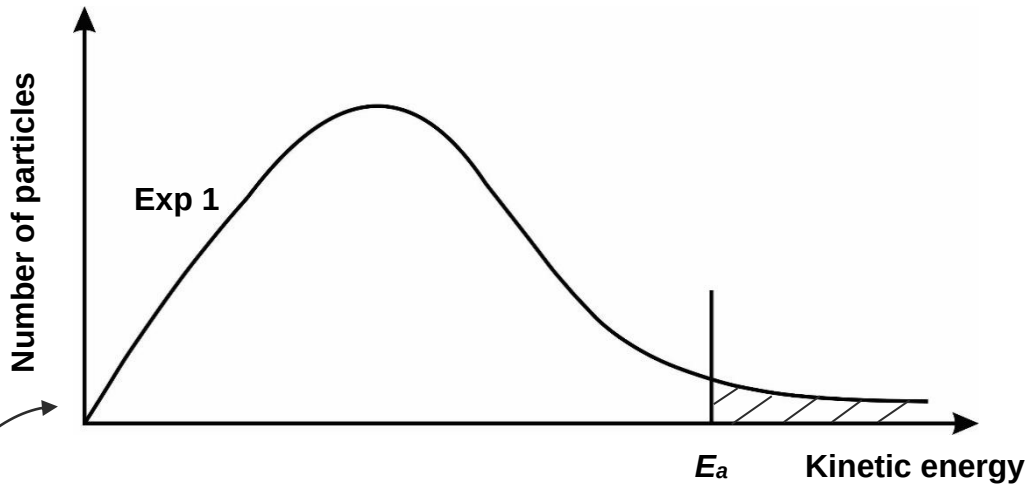
3.3 Can the results of Experiments **2** and **4** be meaningfully compared? Answer YES or NO. Give a reason. (2)

3.4 What conclusion can be reached when Experiment **4** is compared to Experiment **5**? (2)

IEB Copyright © 2024

3.5 Compare Experiment **1** with Experiment **2**. Explain the results with reference to the collision theory. (4)

3.6 The graph below shows the Maxwell–Boltzmann distribution curve for the reaction mixture in Experiment **1**. The activation energy for the reaction, E_a, is marked.



3.6.1 Define *activation energy*. (2)

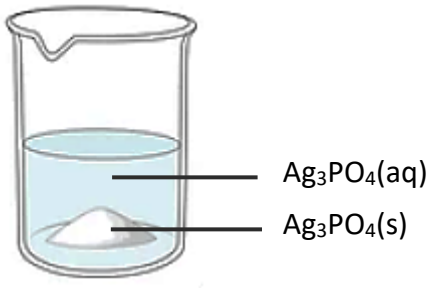
3.6.2 What does the shaded area on the graph indicate? (2)

3.6.3 **On the graph above**, draw a new distribution curve for the reaction mixture in Experiment **3**. Label this curve as **Exp 3**. (2)

[20]

QUESTION 4

The image shows a saturated aqueous solution of Ag_3PO_4 at 25 °C.



4.1 Explain why this can be classified as a *closed system*. (2)

The equation below represents the equilibrium reaction occurring in the solution:

$$Ag_3PO_4(s) \rightleftharpoons 3Ag^+(aq) + PO_4^{3-}(aq) \qquad \Delta H > 0$$
$$K_c = 8{,}9 \times 10^{-17} \text{ at } 25\ °C$$

4.2 Give the name of Ag_3PO_4. (2)

4.3 Circle the correct answers within the brackets:

4.3.1 The forward reaction is (a DISSOCIATION / an IONISATION) reaction. (1)

4.3.2 The value of K_c indicates that the yield is extremely (HIGH / LOW). (1)

4.4 Write the expression for the equilibrium constant of this reaction. (2)

IEB Copyright © 2024

4.5 Show that the concentration of the PO_4^{3-} ions in the saturated solution at 25 °C is $4{,}26 \times 10^{-5}$ mol·dm^{-3}. (4)

4.6 Hence calculate the TOTAL number of free ions of the solute present in 0,2 dm^3 of a saturated solution of Ag_3PO_4 at 25 °C. (5)

IEB Copyright © 2024

The reaction equation is rewritten below:

$$Ag_3PO_4(s) \rightleftharpoons 3Ag^+(aq) + PO_4^{3-}(aq) \qquad \Delta H > 0$$
$$K_c = 8{,}9 \times 10^{-17} \text{ at } 25\ °C$$

4.7 How will the **concentration of Ag^+ ions** in the saturated solution be affected in each of the following instances?

Write only INCREASE, DECREASE or REMAIN THE SAME. (3)

4.7.1 The solution is heated: _____

4.7.2 A few crystals of soluble $Na_3PO_4(s)$ are added: _____

4.7.3 A few crystals of $Ag_3PO_4(s)$ are added: _____

4.8 Explain the answer to Question 4.7.1 by applying Le Chatelier's Principle. (3)

_____

_____

_____

_____

_____

_____

_____

4.9 Give a reason for the answer to Question 4.7.3. (1)

_____

_____

_____

_____

[24]

IEB Copyright © 2024

QUESTION 5

The compounds in the table are all diprotic carboxylic acids.

Name	Molar mass ($g \cdot mol^{-1}$)	K_a at 25 °C
Oxalic acid	90,04	$5,6 \times 10^{-2}$
Malonic acid	104,06	$9,1 \times 10^{-3}$
Succinic acid	118,09	$6,2 \times 10^{-5}$
Tartaric acid	150,09	$9,2 \times 10^{-4}$

5.1 Define a *weak acid*. (2)

5.2 Which acid in the table is the weakest? Give a reason for your answer. (2)

5.3 Oxalic acid is $H_2C_2O_4$. The $HC_2O_4^-$ ion is amphiprotic.

5.3.1 Define an *amphiprotic substance*. (2)

5.3.2 Write the formula of the conjugate base of $HC_2O_4^-$. (1)

5.3.3 State whether potassium oxalate, $K_2C_2O_4$, is an acidic, basic or neutral salt. Write an appropriate reaction equation to support your answer. (3)

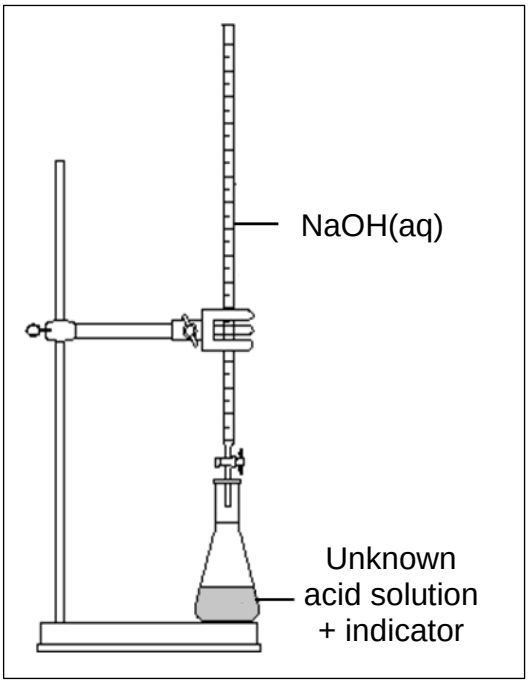
IEB Copyright © 2024

The acids in the table on page 15 are all white crystalline solids at room temperature. Students were required to identify a sample of one of these acids by titration with a standard solution of sodium hydroxide. The acid may be represented as H_2A and the equation for the titration reaction as follows:

$$H_2A + 2NaOH \rightarrow Na_2A + 2H_2O$$

1,0 g of the unknown acid was dissolved in distilled water and made up to a volume of 200 cm^3.

25,0 cm^3 of the unknown acid solution was titrated with the NaOH solution of concentration 0,102 $mol \cdot dm^{-3}$. After a few runs of the titration, the average volume of NaOH used at the end point was 23,5 cm^3.



5.4 Name the apparatus …

5.4.1 containing the NaOH solution. (1)

5.4.2 used to transfer exactly 25,0 cm^3 of the acid solution into the conical flask. (1)

5.5 State what is meant by the terms below. (2)

Equivalence point: _____

End point: _____

5.6 Calculate the molar concentration of the unknown acid solution. Write the answer correct to 4 decimal places. (4)

IEB Copyright © 2024

5.7 Do a suitable calculation to identify the unknown acid from the table on page 15. (5)

5.8 Phenolphthalein indicator was used for the titration. It is a weak acid that may be represented as HIn. The indicator reacts with water according to the equation shown below.

$$\underset{\text{colourless}}{HIn(aq)} + H_2O(\ell) \rightleftharpoons \underset{\text{pink}}{In^-(aq)} + H_3O^+(aq)$$

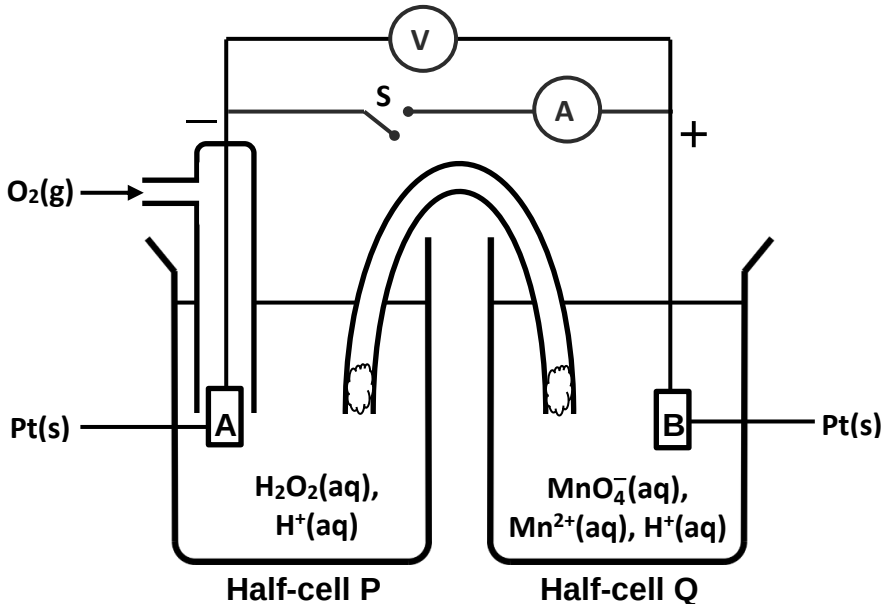
5.8.1 What colour change indicates the end point of this titration? (1)

5.8.2 Apply Le Chatelier's Principle to explain the colour change. (4)

[28]

QUESTION 6

The galvanic cell represented below functions at standard conditions.



6.1 Lizzie suggests that a manganese electrode could be used in half-cell **Q**. Explain why this would not be suitable. (1)

6.2 Identify the cathode in this cell. (1)

6.3 Write down the NAME of the oxidising agent. (1)

6.4 Write the equations for …

6.4.1 the oxidation half reaction. (2)

6.4.2 the reduction half reaction. (2)

6.4.3 the net ionic cell reaction. (3)

IEB Copyright © 2024

6.5 Calculate E^{θ}_{cell} , the reading on the voltmeter when the switch **S** is open. (4)

6.6 When the switch **S** is closed, the reading on the voltmeter decreases. State TWO ways to minimise this decrease in the reading. (2)

6.7 In a different galvanic cell, half cell **Q** functions as the cathode. Zack writes the cell notation for half cell **Q** on the right hand side as follows:

$$(\text{anode}) \,||\, Pt(s) \,|\, MnO_4^-(aq) \,|\, 8H^+(aq) \,|\, Mn^{2+}(aq)$$

Standard conditions were not required. Identify THREE different errors that Zack made in the format of the cell notation. (3)

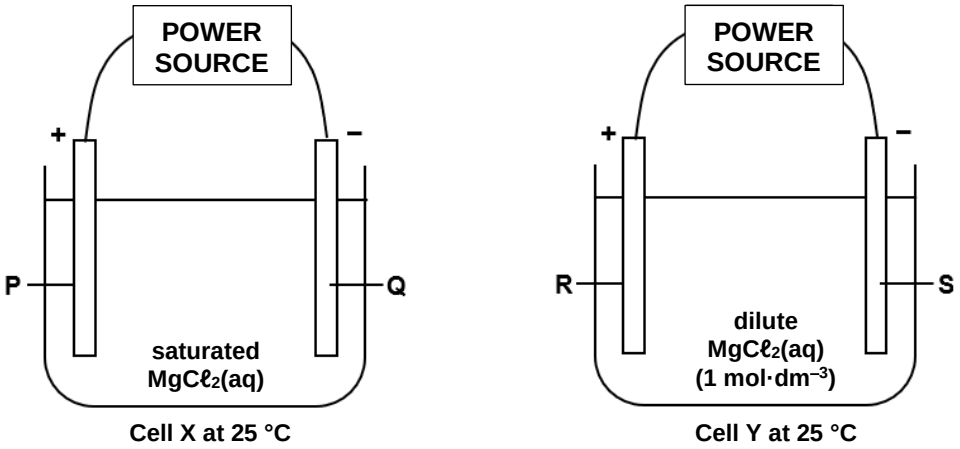
6.8 The electrolyte solutions in both half-cells need to be acidified. Give a reason why H_2SO_4 and **not** HCℓ should be used in half-cell **Q**. Use the table of standard electrode potentials to assist you. (3)

[22]

IEB Copyright © 2024

QUESTION 7

Consider the cells represented below. **P**, **Q**, **R** and **S** are graphite electrodes.



Cell X at 25 °C **Cell Y at 25 °C**

7.1 What type of electrochemical cell is represented by **X** and **Y**? (1)

7.2 Circle the correct word within the brackets: (1)

In this type of cell, reduction takes place at the (POSITIVE / NEGATIVE) electrode.

7.3 The chemical substances that form preferentially at electrodes **Q** and **S** are **the same**. Identify these products. Use the table of standard electrode potentials to assist you. (2)

7.4 The solubility of $MgC\ell_2 \cdot 6H_2O$ in water at 25 °C (i.e. the maximum amount that will dissolve) is 55 g per 100 cm^3 of solution. Calculate the molar concentration of the **chloride ions** in the saturated solution in cell **X**. (5)

IEB Copyright © 2024

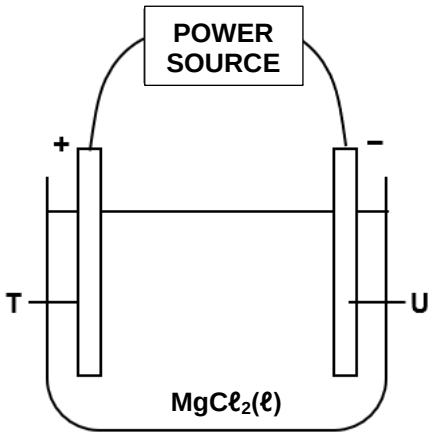
7.5 The chemical substances that form preferentially at electrodes **P** and **R** are **different**. Identify these substances. Use the table of standard electrode potentials to assist you. (3)

Electrode **P** _____

Electrode **R** _____

7.6 Refer to the cell conditions to explain why different products form at electrodes **P** and **R**. (6)

7.7 Now consider Cell **Z** shown below, in which **T** and **U** are also graphite electrodes.



Cell Z at 750 °C

7.7.1 Define *electrolyte*. (2)

7.7.2 Explain briefly why a much higher temperature is needed for Cell **Z**. (2)

7.7.3 Identify the chemical substances that form at: (2)

Electrode **T** _____

Electrode **U** _____

[24]

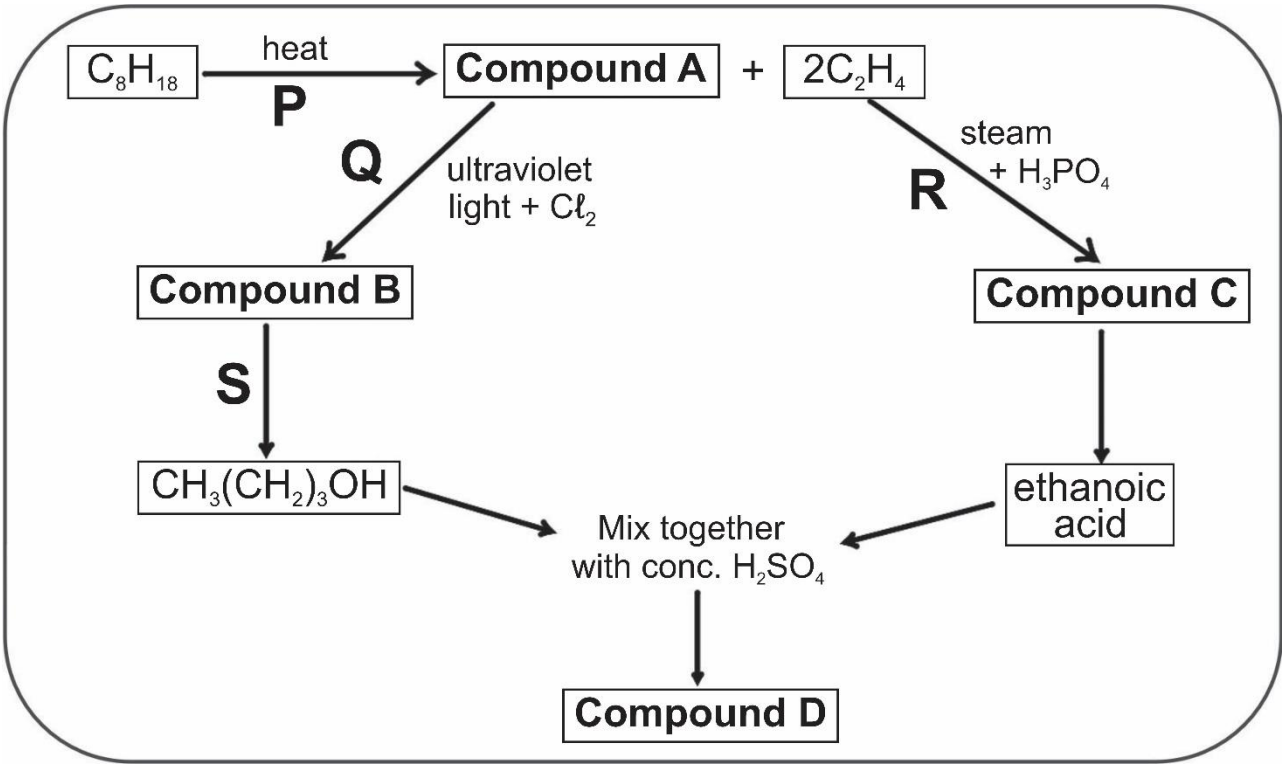
IEB Copyright © 2024

THIS PAGE IS INTENTIONALLY LEFT BLANK.

IEB Copyright © 2024

QUESTION 8

Most organic compounds are synthesised by a multi-step process. The reaction sequence below shows how a banana-flavoured essence (Compound **D**) can be formed: The letters **P**, **Q**, **R** and **S** represent reaction types. Compounds **A**, **B**, **C** and **D** are organic compounds.



8.1 Give the **molecular** formula of Compound **A**. (2)

_____

8.2 Give the IUPAC name of compound:

8.2.1 **B** _____ (3)

8.2.2 **C** _____ (2)

8.2.3 **D** _____ (2)

8.3 Define *homologous series*. (3)

_____

_____

_____

_____

IEB Copyright © 2024

8.4 State the homologous series to which each of Compounds **C** and **D** belong.

8.4.1 **C** _____ (1)

8.4.2 **D** _____ (1)

8.5 Draw the **structural** formula of Compound **D**. (2)

8.6 Give the IUPAC name of an unsaturated hydrocarbon in the flowchart. (2)

_____

_____

_____

8.7 Give the GENERAL reaction type for reaction:

8.7.1 **P** _____ (1)

8.7.2 **Q** _____ (1)

8.8 Give the SPECIFIC reaction type for reaction:

8.8.1 **R** _____ (1)

8.8.2 **S** _____ (1)

IEB Copyright © 2024

8.9 Compound **B** can react with KOH under two reaction conditions:

I Use a hot concentrated solution of KOH in ethanol solvent

II Heat under reflux with dilute aqueous KOH solution

8.9.1 Which of these reaction conditions applies to reaction **S**? (1)

Choose and circle the correct option: **I** OR **II**

8.9.2 Now consider the reaction condition NOT chosen in Question 8.9.1.

(a) State the SPECIFIC type of reaction that will take place when Compound **B** reacts with KOH under these alternative conditions. (1)

(b) Give the IUPAC name of the organic product formed in the reaction in (a). (2)

8.9.3 Organic reaction mixtures often need to be heated for a long time to speed up the reaction. Give a reason why this heating needs to take place 'under reflux'. (1)

8.10 Concentrated H_2SO_4 is used in the final step to form compound **D**.

8.10.1 State the consequence of NOT using H_2SO_4 in this step. (1)

8.10.2 Which **one** of reactions **P**, **Q**, **R** or **S** could be reversed if the products were treated with hot concentrated H_2SO_4? (2)

IEB Copyright © 2024

8.11 Consider the organic product of reaction **S**, the compound $CH_3(CH_2)_3OH$.

8.11.1 Draw the **structural** formula of a CHAIN isomer of this compound. (2)

8.11.2 Give the IUPAC name of a POSITIONAL isomer of $CH_3(CH_2)_3OH$. (2)

8.12 One isomer of C_8H_{18} has a one-carbon side chain and a two-carbon side chain attached to the **same** carbon atom in the main chain. Give the IUPAC name of this isomer. (3)

8.13 Which one of the compounds below will have the highest boiling point? (2)

Circle the correct answer.

octane OR oct-1-ene OR the isomer in Question 8.12

[39]

Total: 200 marks

IEB Copyright © 2024

ADDITIONAL SPACE (ALL QUESTIONS)

REMEMBER TO CLEARLY INDICATE AT THE QUESTION THAT YOU USED THE ADDITIONAL SPACE TO ENSURE THAT ALL ANSWERS ARE MARKED.

IEB Copyright © 2024