

[0500/192]

1988

SCOTTISH CERTIFICATE OF EDUCATION

CHEMISTRY

Higher Grade—PAPER II

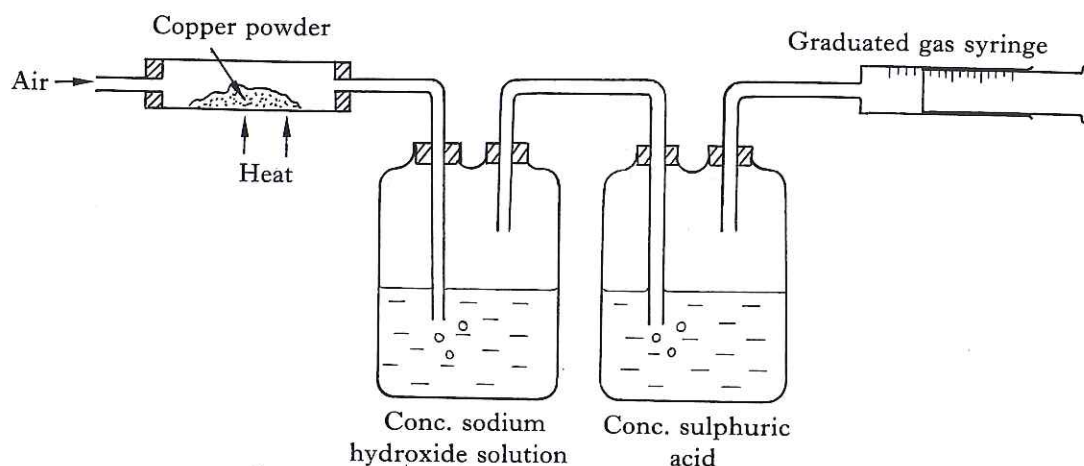
Friday, 6th May—1.30 p.m. to 4.00 p.m.

Candidates are reminded that 4 marks are allocated for communication skills, assessed in Part B of this paper.

Working should be shown in all answers involving calculations.

Necessary tables and data will be found in the booklets of Mathematical Tables and Science Data (1982 editions).

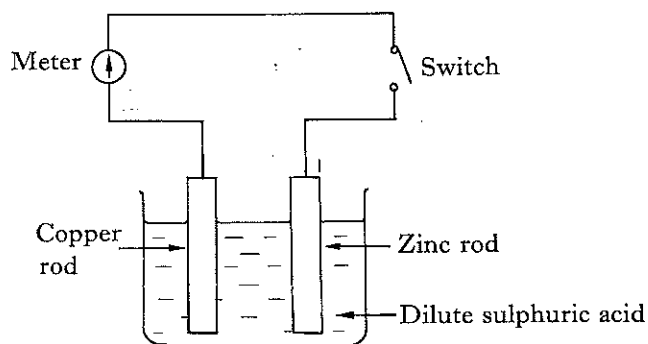
Questions 1 and 2 refer to the experiment illustrated below.



The above apparatus was set up to prepare nitrogen from the air. A slow stream of air was passed over the hot copper powder and nitrogen collected in the gas syringe.

- If 200 cm^3 of air was passed through the apparatus and the gas collected allowed to cool, approximately what volume of gas would be collected in the syringe?
 - 20 cm^3
 - 80 cm^3
 - 160 cm^3
 - 200 cm^3
- The gas collected would not have been pure. Which of the following impurities would have been present?
 - Carbon dioxide
 - Sulphur dioxide
 - Water vapour
 - Noble gases
- When heated in air, a mineral gave off a colourless acidic gas which did not change the colour of iodine solution. The mineral could be
 - galena (a sulphide of lead)
 - haematite (an oxide of iron)
 - malachite (a carbonate of copper)
 - barytes (a sulphate of barium).
- Which statement **cannot** be true of two atoms with the same mass number?
 - They are isotopes of the same element.
 - They have different numbers of protons.
 - They have different numbers of neutrons.
 - They are atoms of two different elements.
- Which of the following forms stable, monatomic molecules?
 - Bromine gas
 - Methane gas
 - Sodium chloride crystals
 - Helium gas
- When 50 cm^3 of sodium hydroxide solution was neutralised with 2 M hydrochloric acid, the final volume of the mixture was 110 cm^3 . What conclusion may be correctly drawn from this result?
 - 10 cm^3 of water was formed during the reaction.
 - The sodium hydroxide solution was more concentrated than the hydrochloric acid.
 - The final solution had a pH greater than 7.
 - The final volume would be about 100 cm^3 after the salt formed was filtered off.

Questions 7 and 8 refer to the following diagram:



7. With the switch open and no current flowing, what would be observed at the metal rods?
- Blue colour at copper rod
 - Gas evolved at zinc rod
 - Gas evolved at copper rod
 - Gas evolved at both rods
8. With the switch closed and a current flowing, which of the following is correct?
- Electrons flow from zinc to copper in the external circuit.
 - Electrons flow from copper to zinc in the external circuit.
 - Electrons flow from zinc to copper in the solution.
 - Electrons flow from copper to zinc in the solution.
9. An iron nail is covered with water. Which of the following procedures would **not** increase the rate at which the iron nail corrodes?
- Adding some sodium hydroxide to the water
 - Attaching a copper wire to the nail
 - Passing carbon dioxide through the water
 - Adding some glucose to the water

Questions 10 and 11 refer to the following changes which may occur during reactions involving nitric acid:

- $\text{H}^+(\text{aq}) + \text{OH}^-(\text{aq}) \rightarrow \text{H}_2\text{O}(\ell)$
- $2\text{H}^+(\text{aq}) + 2\text{e}^- \rightarrow \text{H}_2(\text{g})$
- $\text{NO}_3^-(\text{aq}) + 4\text{H}^+(\text{aq}) + 3\text{e}^- \rightarrow \text{NO}(\text{g}) + 2\text{H}_2\text{O}(\ell)$
- $\text{NO}_3^-(\text{aq}) + 2\text{H}^+(\text{aq}) + \text{e}^- \rightarrow \text{NO}_2(\text{g}) + \text{H}_2\text{O}(\ell)$

Which of the above changes is most likely to occur when

10. magnesium is added to water containing a few drops of dilute nitric acid?
11. ammonia solution is added to dilute nitric acid?
12. Excess barium chloride solution is added to sodium sulphate solution and the precipitate which forms is filtered off. Which of the following reagents, if added to the filtrate, would produce a precipitate?
- Silver nitrate
 - Magnesium nitrate
 - Sodium chloride
 - Calcium chloride
13. Molar solutions of the following substances are electrolysed using platinum electrodes. Which would result in the negative electrode increasing in mass?
- Hydrochloric acid
 - Sodium hydroxide
 - Nickel sulphate
 - Calcium nitrate
14. The sulphite ion, $\text{SO}_3^{2-}(\text{aq})$, is a reducing agent since it
- is formed, along with $\text{H}^+(\text{aq})$ ions, when sulphur dioxide dissolves in water
 - reacts with $\text{Ba}^{2+}(\text{aq})$ ions to form a precipitate of barium sulphite
 - can change a solution containing bromine molecules into one containing $\text{Br}^-(\text{aq})$ ions
 - reacts with dilute hydrochloric acid to form sulphur dioxide gas.

15. Which of the following produces a gas when heated with concentrated sulphuric acid?

- A Sodium sulphate.
- B Calcium chloride
- C Magnesium oxide
- D Aluminium hydroxide

16. When a substance is heated with concentrated sulphuric acid, carbon dioxide is liberated. **From this evidence alone**, what is the most precise description you may make of the substance?

- A It is carbon.
- B It contains carbon.
- C It contains carbon and oxygen.
- D It contains carbon, hydrogen and oxygen.

17. Which of the following molecules is **most** likely to be found in petrol?

- A CH₄
- B C₃H₈
- C C₈H₁₈
- D C₁₄H₃₀

18. Some air is contained in a flask and a series of electric sparks is passed through it. After some time, a little water is added to the flask. What happens?

- A Some of the gas dissolves and an acid solution is formed.
- B Some of the gas dissolves and an alkaline solution is formed.
- C Some of the gas dissolves and a neutral solution is formed.
- D None of the gas dissolves.

19. Which heated substance can be used to oxidise ammonia to nitrogen and water?

- A Iron
- B Platinum
- C Copper(II) oxide
- D Aluminium oxide

20. Which of the following is the best explanation of the action of nitric acid on copper? The acid is acting as

- A a typical acid
- B an oxidising agent
- C a nitrate
- D an ionic solution.

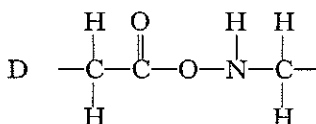
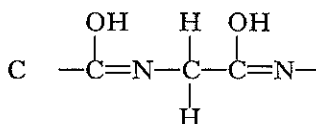
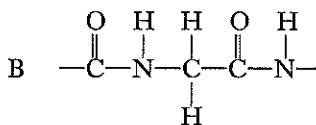
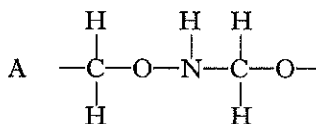
21. The reaction:



is an example of

- A photosynthesis
- B hydrolysis
- C combustion
- D hydration.

22. Which of the following represents part of a protein structure?



23. Which of the following substances would evolve an alkaline gas when heated with soda-lime?

- A Starch
- B Cotton
- C Wool
- D Paper

24. Which of the following is used as a monomer?

- A Nylon
- B Styrene
- C Protein
- D Cellulose

25. Some carbon dioxide is admitted to a mass spectrometer. Which of the following ions will be deflected **most**?

- A $^{12}\text{CO}_2^+$
- B $^{12}\text{CO}_2^{2+}$
- C $^{14}\text{CO}_2^+$
- D $^{14}\text{CO}_2^{2+}$

26. Starting from a given element, which series of radioactive transformations will produce an isotope of the original element?

- A α, β, β
- B β, α, α
- C α, β, γ
- D α, β , neutron capture

27. Radioactive strontium differs from ordinary (non-radioactive) strontium in its

- A atomic mass
- B chemical properties
- C atomic number
- D electron configuration.

28. The Avogadro constant is the same as the number of

- A molecules in 16 g of oxygen
- B ions in 1 litre of molar sodium chloride solution
- C molecules in 2 g of hydrogen
- D atoms in 24 g of carbon.

29. How many litres of oxygen at s.t.p. are needed to burn completely 1 mole of magnesium?

- A 11.2
- B 16.0
- C 22.4
- D 32.0

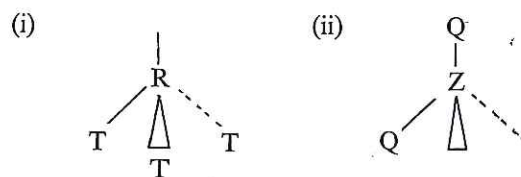
30. In which of the following reactions will the volume of the gaseous products be greater than that of the reactants, all measurements being made at 1 atmosphere pressure and 383 K?




- A $\text{C} + \text{O}_2 \rightarrow \text{CO}_2$
- B $\text{N}_2 + \text{O}_2 \rightarrow 2\text{NO}$
- C $\text{C}_2\text{H}_4 + 3\text{O}_2 \rightarrow 2\text{CO}_2 + 2\text{H}_2\text{O}$
- D $\text{C}_3\text{H}_8 + 5\text{O}_2 \rightarrow 3\text{CO}_2 + 4\text{H}_2\text{O}$

31. A mixture of sodium chloride and sodium sulphate is known to contain 0.6 mole of chloride ion and 0.2 mole of sulphate ion. The number of moles of sodium ion present is

- A 0.4
- B 0.5
- C 0.8
- D 1.0

Questions 32 and 33 refer to the following diagrams which represent molecules.



where  represents an electron pair in the plane of the paper,
 represents an electron pair in front of the plane of the paper,
 represents an electron pair behind the plane of the paper.

32. Which of the following elements could make up structure (i)?

- | | R | T |
|---|-----------|----------|
| A | nitrogen | hydrogen |
| B | hydrogen | nitrogen |
| C | carbon | hydrogen |
| D | beryllium | chlorine |

33. Which of the following elements could make up structure (ii)?

- | | Z | Q |
|---|------------|----------|
| A | oxygen | hydrogen |
| B | hydrogen | oxygen |
| C | beryllium | hydrogen |
| D | phosphorus | hydrogen |

34. When 3.0 g of ethane gas (formula mass = 30) is burned, 156 kJ of energy is given out. What is the enthalpy of combustion of ethane?

- A $\frac{22.4 \times 3.0 \times 156}{30} \text{ kJ mol}^{-1}$
 B $\frac{22.4 \times 30 \times 156}{3.0} \text{ kJ mol}^{-1}$
 C $\frac{3.0 \times 156}{30} \text{ kJ mol}^{-1}$
 D $\frac{30 \times 156}{3.0} \text{ kJ mol}^{-1}$

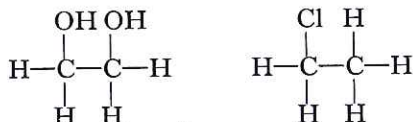
35. Which of the following properties would be expected to apply to the metal francium?

- A It will resist corrosion.
 B It will form a covalent chloride.
 C It will form a soluble hydroxide.
 D It will have a very stable nucleus.

36. When a Group I metal atom, X, reacts to become an ion, X^+ ,

- A the diameter of the particle decreases
 B the positive charge of the nucleus increases
 C the atomic number of X decreases
 D the number of electron shells increases by 1.

37.



(Substance X, molecular mass 62) (Substance Y, molecular mass 64.5)

From a consideration of chemical bonding, what can you predict about the boiling points of these compounds?

- A Boiling point of X is greater than that of Y.
 B Boiling point of X is less than that of Y.
 C Boiling point of X is approximately equal to that of Y.
 D Nothing.

38. Which of the following is held together entirely by van der Waals' forces?

- A Solid potassium fluoride
 B Solid argon
 C Solid sodium
 D Solid silicon dioxide

39. Metallic calcium is obtained by an electrolytic method rather than by any other method because

- A calcium has a high electron affinity
 B calcium ions are difficult to reduce
 C all calcium compounds are insoluble in water
 D all calcium compounds are ionic.

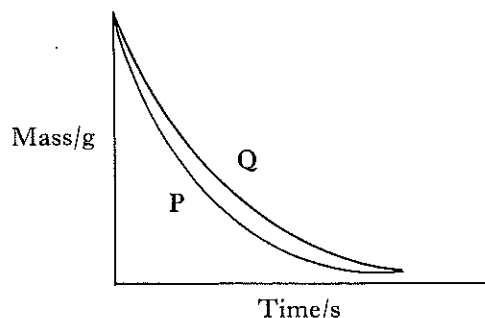
40. Hydrogen is liberated at the positive electrode during the electrolysis of

- A an aqueous solution of sodium chloride
 B molten sodium hydroxide
 C an aqueous solution of sodium hydroxide
 D molten sodium hydride.

41. Which of the following does **not** react with bromine?

- A Sodium sulphite solution
 B Sodium metal
 C Potassium iodide solution
 D Sodium chloride solution

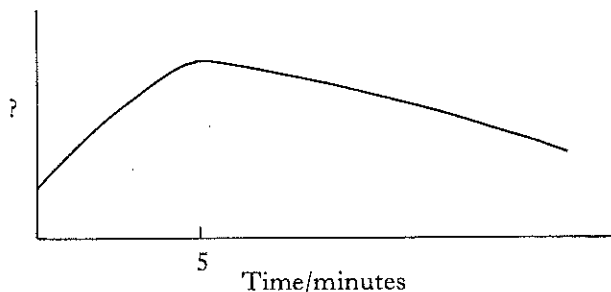
42. The course of the reaction between magnesite (magnesium carbonate) and dilute hydrochloric acid was followed by determining the mass of the reaction vessel and contents as carbon dioxide was evolved. The rate curves obtained under two different conditions P, and Q, are shown in the graph below:



The change in the form of the rate curve from P to Q would be obtained by

- A increasing the concentration of the acid
 - B increasing the temperature of the reactants
 - C decreasing the particle size of the magnesite
 - D increasing the pressure in the reaction vessel.
43. During the addition of magnesium granules to excess, dilute hydrochloric acid, each of the following was measured and plotted against time on a graph.
- A The temperature of the solution
 - B The volume of hydrogen produced
 - C The pH of the solution
 - D The conductivity of the solution

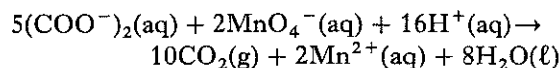
If the reaction was completed in 5 minutes, which of the above would give the graph below?



44. From a knowledge of the following reactions, which is most likely to have the **lowest** Activation Energy?

- A $2\text{H}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{H}_2\text{O}(\text{g})$
- B $2\text{CO}(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{CO}_2(\text{g})$
- C $2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{SO}_3(\text{g})$
- D $2\text{NO}(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{NO}_2(\text{g})$

45. The reaction between oxalate ions and permanganate ions in the presence of hydrogen ions can be summarised:



When a little permanganate solution is added to the hot (70°C) acidic oxalate solution, there is a time lag before the purple colour disappears. With further additions of permanganate, the colour disappears instantly. Which of the following statements is a reasonable explanation of this?

- A The $\text{Mn}^{2+}(\text{aq})$ formed catalyses the reaction.
- B Oxalic acid is an organic acid.
- C The acid is a catalyst for the reaction.
- D The activation energy for the reaction is high.

46. A mixture of 50 cm^3 carbon monoxide and 40 cm^3 carbon dioxide is passed through an aqueous solution of sodium hydroxide and then over heated copper(II) oxide until no further volume change occurs. What is the volume of the remaining gas? (All volumes measured under the same conditions of temperature and pressure.)

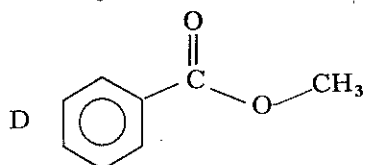
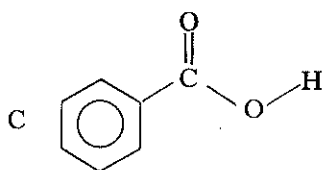
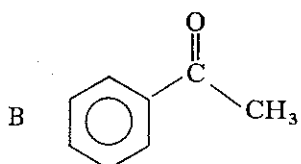
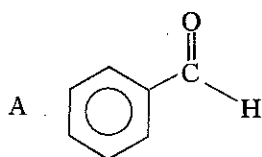
- A 40 cm^3
- B 50 cm^3
- C 90 cm^3
- D 140 cm^3

47. When the vapour of a liquid, X, is passed over heated copper(II) oxide, a reaction occurs and the vapour produced gives an orange precipitate with Benedict's (or Fehling's) solution.

Which of the following could be X?

- A Propan-1-ol
- B Propan-2-ol
- C Propanal
- D Propanone

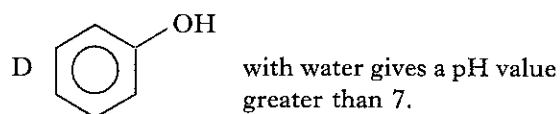
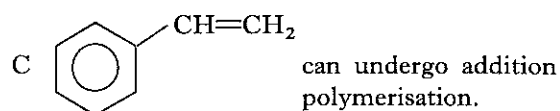
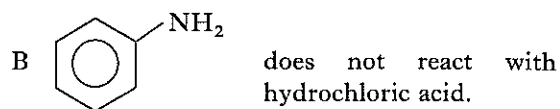
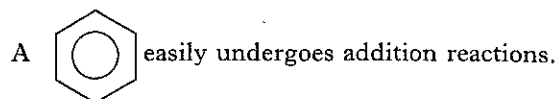
48. Which of the following is the formula of a ketone?



49. When ethanol is passed over heated aluminium oxide, the main product is

- A ethane
- B ethene
- C ethanal
- D ethanoic acid.

50. Which of the following is true?



[END OF QUESTION PAPER]

PART A (48 marks)

All questions should be attempted. It should be noted, however, that questions 5 and 12 contain a choice.

It is suggested that about 1½ hours be spent on this part of the paper.

Marks

1. Name the type of chemical reaction in each of the following:
 - (a) $\text{Pb}(\text{NO}_3)_2(\text{aq}) + 2\text{NaI}(\text{aq}) \rightarrow \text{PbI}_2(\text{s}) + 2\text{NaNO}_3(\text{aq})$ 1
 - (b) $\text{PCl}_5(\text{s}) + \text{H}_2\text{O}(\ell) \rightarrow \text{POCl}_3(\ell) + 2\text{HCl}(\text{g})$ 1

(2)

2. (a) Explain the change in atomic (covalent) radius of the elements
 - (i) across the Periodic Table from lithium to fluorine;
 - (ii) down Group I from lithium to caesium. 2
 (b) Which two elements, of all those considered in (a), form the compound with most ionic character? 1

(3)

3. When an aqueous solution of sodium hydroxide is electrolysed, oxygen is formed at the positive electrode.

$$4\text{OH}^-(\text{aq}) \rightarrow 2\text{H}_2\text{O}(\ell) + \text{O}_2(\text{g}) + 4\text{e}^-$$
 If the volume of oxygen formed (at s.t.p.) is 112 cm³, calculate
 - (a) the number of moles of electrons involved; 3
 - (b) the actual number of electrons this represents. 1

(4)

4. (a) Part of a radioactive decay series is shown below.

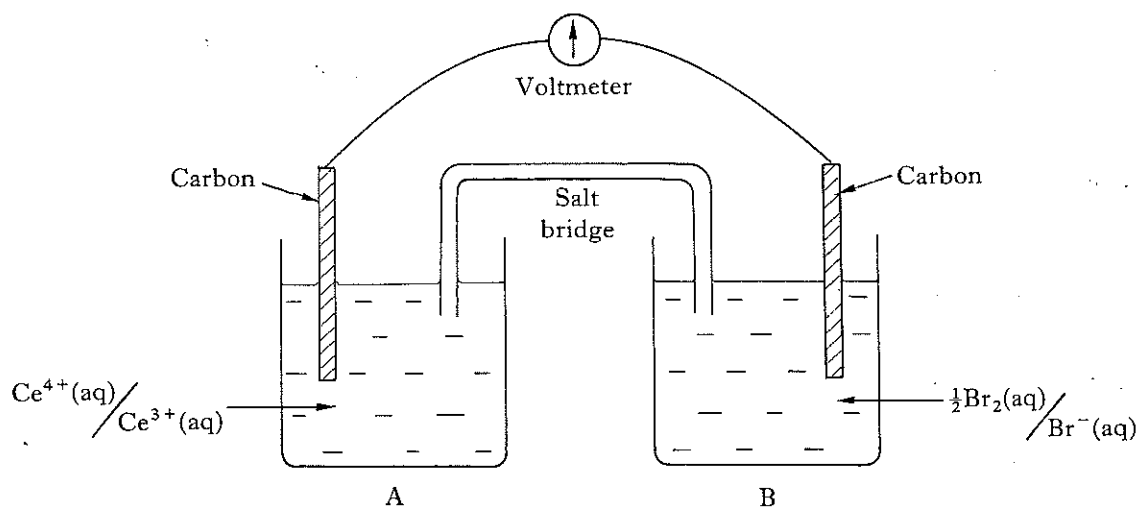
$${}_{90}^{231}\text{Th} \xrightarrow[\text{decay}]{\beta} \text{isotope X} \longrightarrow \text{isotope Y} \xrightarrow[\text{decay}]{\beta} {}_{90}^{227}\text{Th}$$
 - (i) Identify isotopes X and Y. 2
 - (ii) Which type of decay occurs between isotope X and isotope Y? 1
 (b) The radioactive isotope ${}_{84}^{210}\text{Po}$ decays to ${}_{82}^{206}\text{Pb}$, which is stable. Calculate the mass of lead which would be formed from 1 mole of ${}_{84}^{210}\text{Po}$ after **two** half-lives. 2

(5)

5. Answer **EITHER A OR B**.
 - A. $\text{CH}_3\text{NHNH}_2(\ell) + 2\frac{1}{2}\text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g}) + 3\text{H}_2\text{O}(\ell) + \text{N}_2(\text{g}) \quad \Delta\text{H} = -1305 \text{ kJ mol}^{-1}$
methylhydrazine
Using the above information, together with information on page 2 of the Data Booklet, calculate the Enthalpy of Formation of methylhydrazine. (5)

 - OR**
 - B. $\text{Si}_2\text{H}_6(\text{g}) \rightarrow 2\text{Si}(\text{s}) + 3\text{H}_2(\text{g}) \quad \Delta\text{H} = -78 \text{ kJ mol}^{-1}$
disilane
Given that the Enthalpy of Sublimation of silicon is 439 kJ mol⁻¹, use the above information, together with information on page 7 of the Data Booklet, to calculate the bond enthalpy of the Si-H bond in disilane. (5)

6.



The half-reaction $\text{Ce}^{4+}(\text{aq}) + \text{e}^{-} \rightarrow \text{Ce}^{3+}(\text{aq})$ has a Standard Reduction Potential of +1.45 V.

- (a) In which direction will electrons flow in the external circuit? (Data Booklet, page 6) 1
- (b) What will gradually happen to the colour intensity of the solution in beaker B as the cell is operating? 1
- (c) Write a balanced ionic equation for the overall reaction. 1
- (3)

7. A compound has the following percentage composition by mass:

Element	Hydrogen	Nitrogen	Oxygen
Percentage composition by mass	5	35	60

- (a) Calculate the empirical (simplest) formula for the compound. 2
- (b) The compound gives a positive "brown ring" test. What is the name of the compound? 1
- (3)

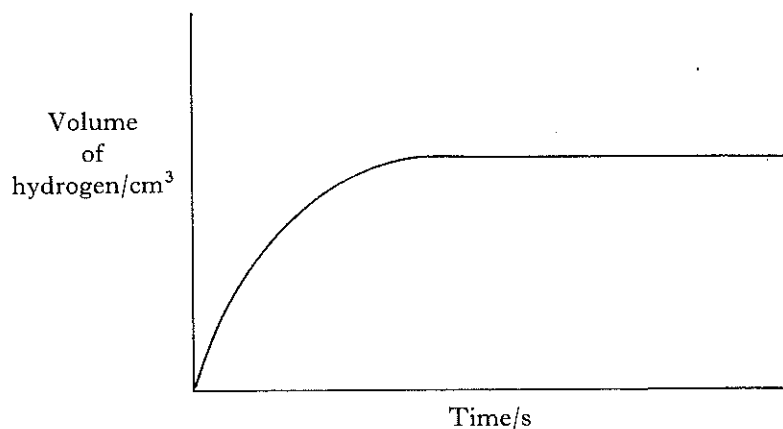
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8. (a) In an experiment on reaction rate, 6.5 g of powdered zinc was added to 25 cm³ of 2 M sulphuric acid.

Show by calculation which reactant was in excess.

3

- (b) The following graph was obtained from the results of the experiment.



Copy the graph into your answer book (no graph paper required) and add a dotted line to represent the graph obtained when the same mass of powdered zinc is added to 25 cm³ of 2 M hydrochloric acid.

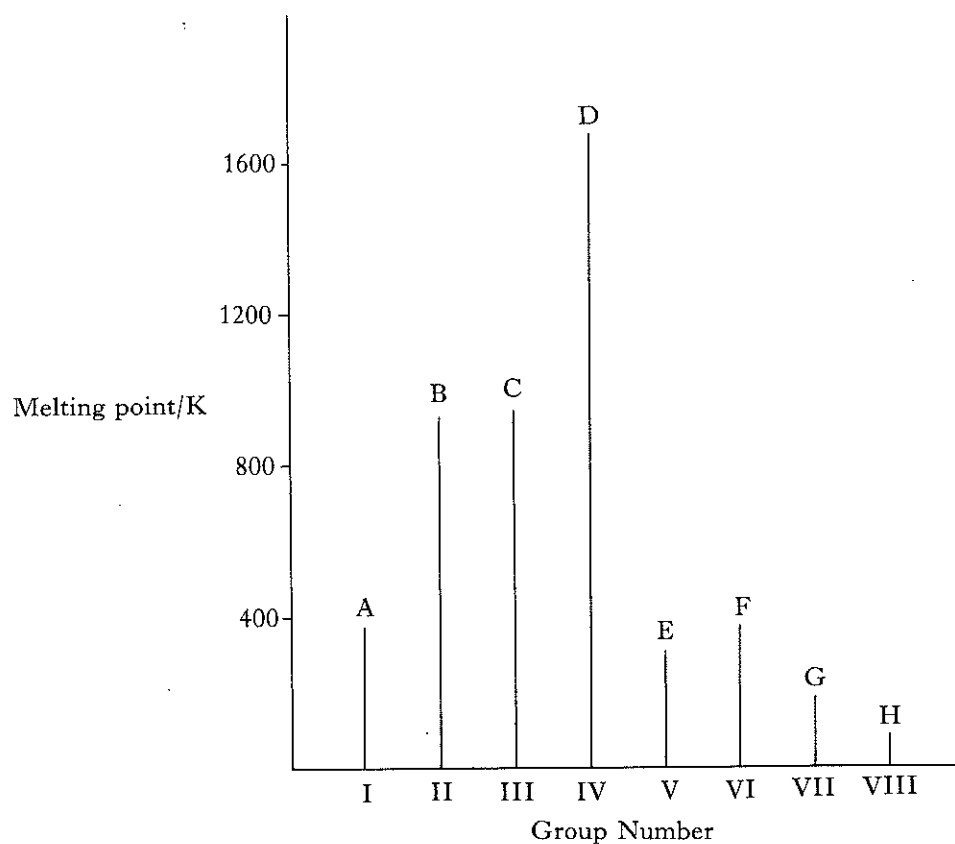
1

(4)

9. A constant current was passed through molten tin(II) chloride for 16 minutes 5 seconds and the mass of tin deposited was 2.38 g. Calculate the current used.

(3)

10.



The graph shows the melting points for the elements across a Period in the Periodic Table.

- (a) Identify the Period represented by the graph. 1
- (b) The bonding in both elements A and B is metallic.
Suggest why the melting point of element B is higher than that of element A. 1
- (c) Elements D and E are both covalently bonded. In terms of structure, account for the large difference in their melting points. 1
- (3)**

11. Using information from the Data Booklet (page 5) show, by calculation, whether iron(II) oxide is more likely to have a crystal structure similar to sodium chloride or similar to caesium chloride. (2)

[Turn over

12. Answer EITHER A OR B

A. Consider the reactions which occur between the reactants shown in boxes "A to F".

$C_2H_4(g) + H_2(g) \rightarrow$ A	$HCOOH(aq) + NaOH(aq) \rightarrow$ B	$CH_3I(l) + KOH(aq) \rightarrow$ C
$HCHO(g) + CuO(s) \rightarrow$ D	$C_2H_5OH(l) + Na(s) \rightarrow$ E	$C_2H_5COOCH_3(l) + NaOH(aq) \rightarrow$ F

Answer the questions which follow by giving the **box reference letter**.

- Which reaction involves the hydrolysis of an ester?
- In which reaction will hydrogen gas be formed?
- Which reaction will produce an **organic product** which in aqueous solution will have a pH less than that of the **organic reactant**?
- Which reaction involves the combination of $H^+(aq)$ and $OH^-(aq)$ ions?
- Which reaction will give a product the same as the organic product obtained in reaction C?

(5)

OR

B. Consider the changes shown in boxes "M to R".

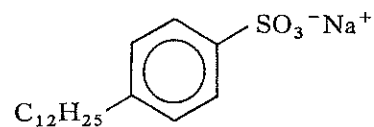
$Cl_2(g) \rightarrow Cl(g) + Cl(g)$ M	$Cl_2(l) \rightarrow Cl_2(g)$ N	$HCl(g) \rightarrow H(g) + Cl(g)$ O
$Cl(g) + H_2(g) \rightarrow HCl(g) + H(g)$ P	$HCl(g) \xrightarrow{water} H^+(aq) + Cl^-(aq)$ Q	$Cl(g) + e^- \rightarrow Cl^-(g)$ R

Answer the questions which follow by giving the **box reference letter**.

- In which change are only van der Waals' forces broken?
- For which change would the ΔH value be the bond enthalpy of a polar covalent bond?
- Which change does not involve any endothermic steps?
- Which change results in a pH decrease?
- Which change could be an intermediate (propagating) step in a chain reaction?

(5)

13.



a sodium sulphonate

- (a) Some sodium sulphonates are used as soapless detergents. They are designed to contain two distinct parts—one hydrophilic (“water loving”), the other hydrophobic (“water hating”).

Draw the part of the above detergent which is hydrophobic.

1

- (b) (i) Give the formulae of **two** ions present in hard water which interfere with the cleansing action of soap.

1

(ii) Explain why these ions do not cause the same problem with soapless detergents.

1

- (c) The above sodium sulphonate is alkaline in aqueous solution.

(i) What does this tell you about the sulphonic acid from which it is made?

1

(ii) Explain why the sodium sulphonate solution is alkaline.

2

(6)

[Turn over

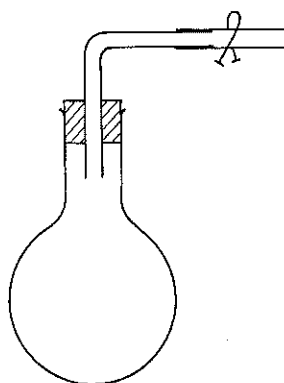
PART B (48 marks)

All four questions should be attempted. It should be noted however that question 17 contains a choice.

Candidates are advised to spend about 1½ hours on this part.

Marks

14. (a) The following apparatus was used to determine experimentally the volume of one mole of sulphur dioxide.



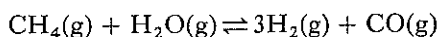
The flask was carefully dried, evacuated, then accurately weighed. Sulphur dioxide was allowed to enter the flask and the apparatus reweighed. The results obtained were:

mass of evacuated flask	= 512.97 g
mass of flask + sulphur dioxide	= 514.57 g
capacity of flask	= 600 cm ³

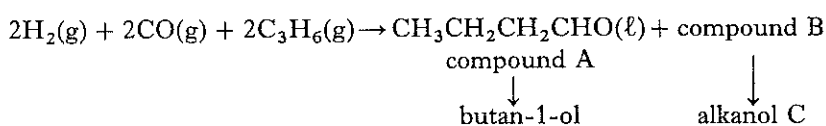
- (i) Use these results to calculate the volume of 1 mole of sulphur dioxide (under the experimental conditions of temperature and pressure). 2
- (ii) Give a reason why the apparatus has to be dry before the experiment is carried out. 1
- (iii) Describe how the capacity of the flask could be measured experimentally. 1
- (iv) Using the same flask, the experiment was repeated with gas X which was known to have a density of $2.14 \times 10^{-3} \text{ g cm}^{-3}$.
Explain whether the result "mass of flask + gas X" should be greater than or less than 514.57 g. (Data Booklet page 9) 1
- (b) The conversion of sulphur dioxide to sulphur trioxide is an equilibrium reaction. Assuming an equilibrium situation exists in which only 50% of the available sulphur dioxide is converted to sulphur trioxide, calculate the volume and composition of the resulting gas mixture when 100 cm³ of sulphur dioxide is mixed with 100 cm³ (excess) oxygen. 3
- (c) In another experiment, sulphur dioxide was dissolved in water to give sulphurous acid solution.
Given 0.1 M sodium hydroxide solution, describe
- (i) how you would determine experimentally the molarity of the sulphurous acid solution; 2
- (ii) how you would work out the results. 2

(12)

15. Synthesis gas, a mixture of hydrogen and carbon monoxide, is prepared as shown below. Nickel is known to catalyse the reaction.



- (a) (i) An increase in temperature increases the yield of synthesis gas. What information does this give about the enthalpy change in the forward reaction? 1
- (ii) Using Le Chatelier's Principle, explain how a change in pressure will affect the composition of the equilibrium mixture. 2
- (iii) State how the rate of formation of synthesis gas will be affected by the use of the catalyst. 1
- (iv) State how the composition of the equilibrium mixture will be affected by the use of the catalyst. 1
- (b) A reaction sequence involving an addition reaction between synthesis gas and propene is shown below.



Compound A and compound B are isomers and belong to the same class of organic compounds.

- (i) Name the class of organic compounds to which A and B belong. 1
- (ii) Draw the full structural formula of compound B and name it. 2
- (iii) If hexan-1-ol was required as a product instead of butan-1-ol, which reagent would be used in place of propene? 1
- (iv) Will alkanol C be primary, secondary or tertiary? 1
- (c) (i) Which type of chemical reaction occurs when butan-1-ol reacts with ethanoic acid in the presence of concentrated sulphuric acid? 1
- (ii) Draw the full structural formula for the organic product in (c) (i). 1

(12)

[Turn over

16. (a) The electrolysis of a saturated, aqueous solution of sodium chloride produces chlorine in commercial quantities at the positive electrode.
- (i) From a consideration of the Standard Reduction Potentials, predict which ion in the solution should be discharged at the positive electrode. (Data Booklet pages 6, 7) 1
- (ii) Explain why, in practice, the chloride ion is discharged. 1
- (iii) Which solution will also be available in commercial quantities as a result of this electrolysis? 1
- (b) A gas jar of dry chlorine can be prepared by adding dilute mineral acid, at a controlled rate, to bleaching powder and drying the resulting gas with concentrated sulphuric acid.
- Draw a labelled diagram of apparatus which could be used to prepare, dry and collect a jar of chlorine gas. 2
- (c) In the redox reaction between solutions of sodium persulphate ($\text{Na}_2\text{S}_2\text{O}_8$) and sodium iodide, persulphate ions are reduced to sulphate ions. Iodine is the other product.
- (i) Write the ion-electron half-reaction equations for this reaction. 2
- (ii) Given that the E° value for the reduction of persulphate ions to sulphate ions is $+2.01\text{ V}$, predict the voltage which would be obtained if the reaction in (i) was carried out in the form of a cell. (Data Booklet page 6) 1

(d)

Halogen	b.p./K	1st Ionisation Energy/ kJ mol^{-1}
Fluorine	85	1690
Chlorine	238	1260
Bromine	332	1150
Iodine	457	1020

Hydrogen halide	b.p./K	Effect of heating
Hydrogen fluoride	293	does not decompose
Hydrogen chloride	159	very slight decomposition
Hydrogen bromide	186	decomposes to some extent
Hydrogen iodide	238	decomposes very readily

State, in each case, the main factor influencing

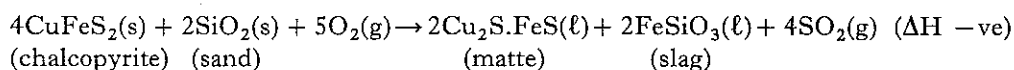
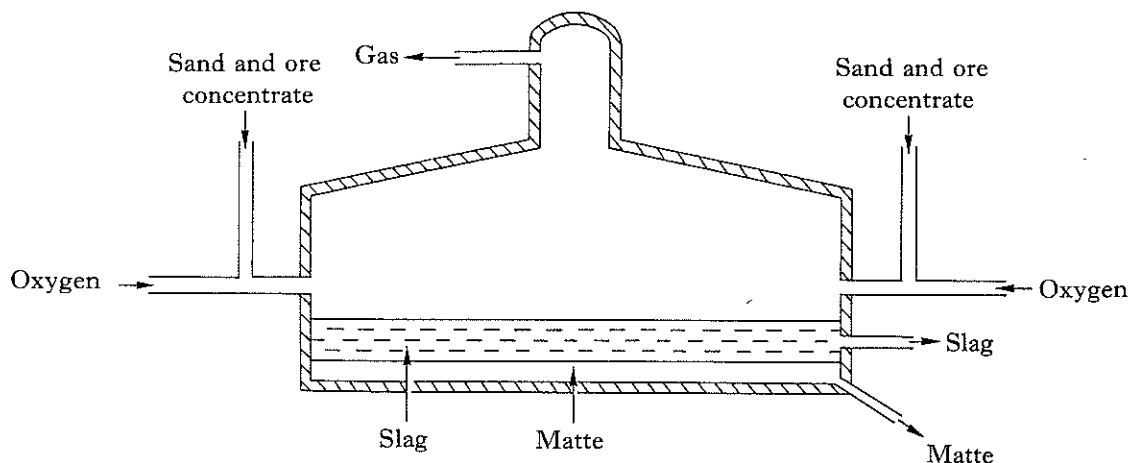
- (i) the steady increase in the boiling points of the halogens; 1
- (ii) the steady decrease in the first Ionisation Energies of the halogens; 1
- (iii) the anomalous boiling point of hydrogen fluoride; 1
- (iv) the different effects of heat on the hydrogen halides. 1
- (12)

17. ANSWER EITHER A OR B

- A. There are two main stages in the extraction of copper from sulphide ores such as chalcopyrite (CuFeS_2).

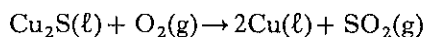
Stage 1 — Matte Smelting

This stage produces a liquid sulphide (called the matte) and a liquid slag. The finely divided concentrated ore is mixed with sand and blown into the furnace by oxygen as shown in the diagram.



Stage 2—Conversion to copper

Air is blown through a mixture of liquid matte and more sand at a temperature of about 1400 K. The iron(II) sulphide content of the matte reacts with oxygen and sand to form more slag and sulphur dioxide. (This reaction is exothermic.) When the iron content of the matte falls to about 1%, impure copper is formed. The equation for this reaction is

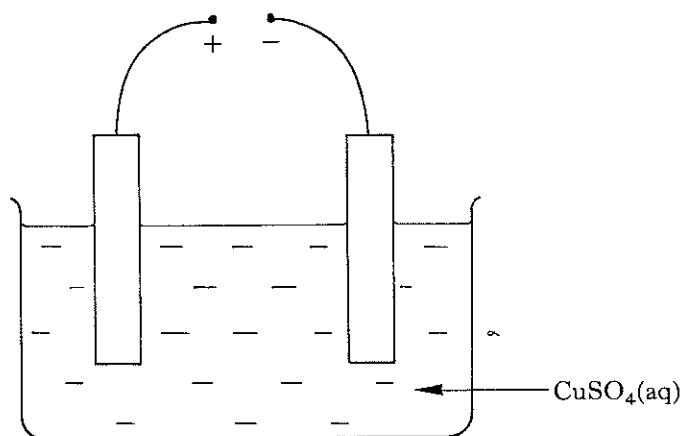


- (a) Why is the ore blown into the furnace as a fine powder? 1
- (b) From the equation, calculate the volume of oxygen (at s.t.p.) required to react completely with 1472 kg of chalcopyrite in Stage 1. 3
- (c) Referring to the diagram, suggest a property of the matte which allows the matte and slag to be tapped off separately. 1
- (d) The whole extraction process is economic as regards use of external fuel. Explain why this is so. 1
- (e) Write a balanced equation for the reaction in Stage 2 when iron(II) sulphide is converted to slag. 2

[Turn over

17. A. (continued)

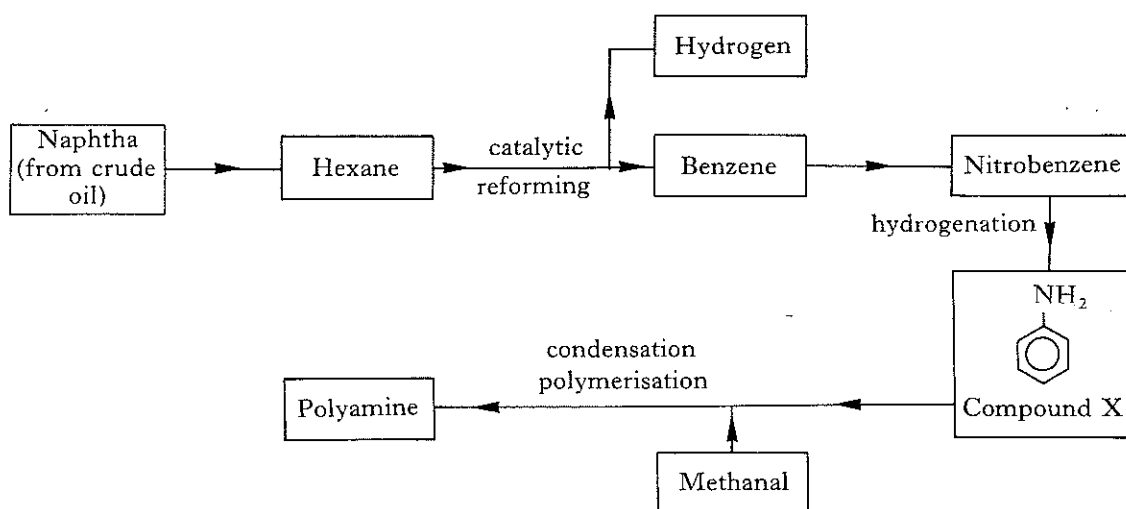
(f) The impure copper can be refined by electrolysis as follows:



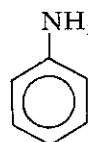
- (i) The impure copper acts as one electrode, with pure copper being used as the other electrode. Which is which? 1
- (ii) Write the ion-electron equations for the half-reactions occurring at the electrodes, indicating which represents oxidation and which represents reduction. 2
- (iii) Explain why iron, present as an impurity, is not deposited on the pure copper electrode. 1
- (12)**

OR

B. The flow diagram shows how a polyamine, used in the preparation of polyurethane foam, is manufactured.



- (a) Name the process by which naphtha is obtained from crude oil. 1
- (b) (i) Write a balanced equation for the reforming of hexane to benzene and hydrogen. 1
- (ii) Calculate the volume of hydrogen (at s.t.p.) produced when 172 g of hexane is reformed. 2
- (c) Give, in relation to the above process, an economic use for this hydrogen. 1
- (d) The hexane often contains an impurity. When one mole of this impurity is reformed, it produces the same volume of hydrogen as hexane, but methylbenzene instead of benzene. Name this impurity. 1
- (e) Which type of chemical reaction takes place when the benzene is converted to nitrobenzene? 1
- (f) (i) Name compound X. 1
- (ii) Write a balanced equation to show the reaction between compound X and hydrochloric acid, showing the ionic product. 1
- (iii) Draw the full structural formula of methanal. 1
- (iv) Draw a possible structure of the compound formed when two molecules of compound X and one molecule of methanal react by a condensation reaction. 1
- (g) The following compounds are basic:



Arrange the three compounds in increasing order of strength as bases. 1

(12)

[END OF QUESTION PAPER]