

[92/232]

1985

SCOTTISH CERTIFICATE OF EDUCATION

CHEMISTRY

Higher Grade—PAPER II

Friday, 10th May—1.30 p.m. to 4.00 p.m.

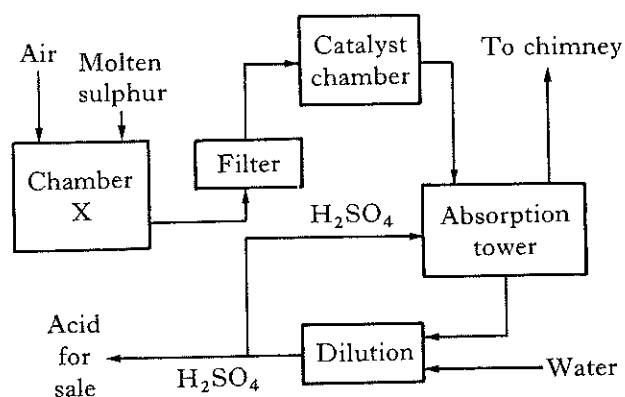
Candidates are reminded that 4 marks in this paper are allocated for communication skills.

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).

1. Which of the following has the same number of neutrons as ${}^{39}_{19}\text{K}$?
- A ${}^{39}_{20}\text{Ca}$
B ${}^{40}_{19}\text{K}$
C ${}^{39}_{18}\text{Ar}$
D ${}^{37}_{17}\text{Cl}$
2. A solution of silver nitrate was made up using tap water. The solution was found to be cloudy. This suggests that the tap water contained
- A barium ions
B chloride ions
C calcium ions
D sodium ions.
3. When an atom X reacts to become an ion X^-
- A the diameter of the particle increases
B the nucleus of X acquires a negative charge
C the atomic number of X increases
D the number of electron shells increases by 1.
4. When 72 g of a metal(II) oxide was completely reduced, 56 g of the metal remained. If the relative atomic mass of oxygen is 16, the relative atomic mass of the metal is
- A 28
B 56
C 112
D 144.
5. Which of the following exists as diatomic molecules?
- A Helium gas
B Methane gas
C Carbon monoxide gas
D Crystalline sodium chloride
6. Which of the following would be expected to react together?
- A Copper and zinc sulphate solution
B Tin and mercury(II) chloride solution
C Silver and dilute sulphuric acid
D Lead and iron(II) sulphate solution
7. Two identical samples of copper(II) carbonate are taken. To one sample is added an excess of 1 M hydrochloric acid; to the other an equal volume of 1 M sulphuric acid. All other conditions are the same.
- Which of the following is different for the two reactions?
- A The mass of copper(II) carbonate dissolved
B The volume of gas liberated
C The mass of water formed
D The hydrogen ion concentration of the remaining solution
8. Aluminium is obtained commercially from its oxide by
- A mixing with carbon and strongly heating
B passing hydrogen gas over the heated oxide
C adding dilute nitric acid and electrolysing the solution
D electrolysing a melt of the oxide.
9. The heat released when 1 litre of 1 M ethanoic acid is mixed with 1 litre of 1 M sodium hydroxide is less than for 1 litre of 1 M hydrochloric acid or 1 litre of 1 M nitric acid because ethanoic acid
- A is monoprotic
B is very slow to react
C is incompletely ionised
D contains four hydrogen atoms.

Questions 10 and 11 refer to the manufacture of sulphuric acid according to the flow diagram below.



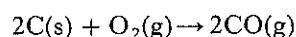
10. Which of the following forms the largest proportion of the gas emitted from the chimney?
- Nitrogen
 - Carbon dioxide
 - Water vapour
 - Sulphur dioxide
11. Which of these equations describes the main reaction taking place in chamber X?
- $2S + 3O_2 \rightarrow 2SO_3$
 - $S + O_2 \rightarrow SO_2$
 - $2SO_2 + O_2 \rightarrow 2SO_3$
 - None of these

12. 50 cm^3 of 2 M sulphuric acid required 100 cm^3 of sodium hydroxide solution for complete neutralisation. The molarity of the sodium hydroxide solution was
- 0.25
 - 0.5
 - 1.0
 - 2.0
13. If concentrated aqueous solutions of the following are electrolysed, which one is **least** likely to involve the breakdown of water?
- Sodium bromide
 - Sodium sulphate
 - Copper bromide
 - Copper sulphate

[Turn over

14. The gas evolved when dilute hydrochloric acid (2M) is added to a mixture of copper turnings and copper(II) carbonate is
- A carbon dioxide only
 - B hydrogen only
 - C a mixture of hydrogen and carbon dioxide
 - D a mixture of carbon dioxide and chlorine.

15. In the reaction



what mass of carbon is required to form 2.24 litres of CO at s.t.p.?

- A 0.6 g
- B 1.2 g
- C 6.0 g
- D 12.0 g

Questions 16 and 17 refer to the following formulae of hydrocarbons.

- A C_5H_{10}
- B C_6H_{10}
- C C_6H_{14}
- D C_7H_8

16. Which could be a cycloalkane?
17. Which could have a structure similar to benzene?
18. Which of the following is used in the laboratory to oxidise ammonia to nitrogen and water?
- A Iron
 - B Platinum
 - C Aluminium oxide
 - D Copper(II) oxide

19. Which of the following statements is true about an aqueous solution of ammonia?

- A It has a pH less than 7.
- B It is completely ionised.
- C It contains an excess of hydroxide ions over hydrogen ions.
- D It reacts with acids, producing ammonia gas.

20. Copper(II) sulphate solution is electrolysed using platinum electrodes. A brown solid is deposited on the negative electrode. To clean the electrode it could be dipped into dilute

- A sulphurous acid
- B ethanoic acid
- C nitric acid
- D hydrochloric acid.

21. When green plants convert carbohydrate to carbon dioxide and water

- A energy is released
- B oxygen is released
- C chlorophyll acts as a catalyst
- D the process is called photosynthesis.

22. An unknown liquid X is diluted with an equal volume of water and the resulting solution is found to have a low conductivity and to give hydrogen on addition of magnesium. X is most likely to be

- A sodium hydroxide solution
- B concentrated hydrochloric acid
- C ethanol
- D ethanoic acid.

23. Glycerol can be obtained from a fat by

- A electrolysis
- B condensation
- C hydrolysis
- D esterification.

24. A condensation polymer is classed differently from an addition polymer since the condensation polymer is

- A a straight chain hydrocarbon
- B resoftened on heating
- C formed by eliminating small molecules
- D formed by combination of monomers.

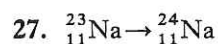
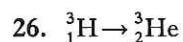
25. Which of the following can be used to make fabrics water-repellent?

- A Silicon
- B Silicones
- C Silica
- D Silicates

Questions 26 and 27 refer to the following processes occurring in nuclear transformations.

- A Alpha emission
- B Beta emission
- C Proton capture
- D Neutron capture

Which of the above processes takes place in the following transformations?



28. ${}^{210}_{84}\text{Po}$ is an α -emitter with a half life of 140 days, giving a stable decay product. What percentage of the original isotope would remain after 420 days?

- A 12.5
- B 25
- C 75
- D 87.5

29. If a steady current of 0.4 A is passed through molar silver nitrate solution for 40 minutes, how many moles of silver will be liberated?

- A 0.001
- B 0.01
- C 0.1
- D 1.0

30. An element conducts electricity. When it is burned in oxygen and the product added to water, the resulting solution has a pH greater than 7. The element could be

- A carbon
- B sodium
- C sulphur
- D iron.

31. What volume of chlorine at s.t.p. will be produced when 1 mole of hydrochloric acid reacts according to the equation



- A 5.6 litres
- B 11.2 litres
- C 22.4 litres
- D 89.6 litres

32. How many litres of oxygen at s.t.p. are needed to react completely with 1 mole of zinc?

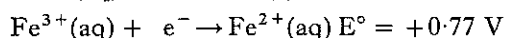
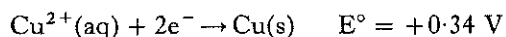
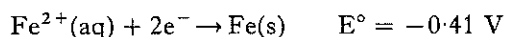
- A 11.2
- B 22.4
- C 32.0
- D 44.8

33. Which of the following alkanols will give 7 moles of carbon dioxide when 1 mole of it is completely burned?

- A $\text{CH}_3\text{CH}_2\text{CH}(\text{OH})\text{CH}(\text{CH}_3)_2$
- B $(\text{CH}_3)_3\text{CCH}_2\text{OH}$
- C $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}(\text{OH})\text{CH}_2\text{CH}_2\text{CH}_3$
- D $\text{CH}_3\text{CH}_2\text{CH}(\text{OH})\text{CH}_3$

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34. The following table shows the standard reduction potentials (E°) for three half cells.



From a study of these values it is reasonable to expect that when copper metal is put into a solution containing a mixture of iron(III) and iron(II) ions

- A a precipitate of iron will be formed
 B no reaction will take place
 C iron(II) ions will be oxidised to iron(III) ions
 D copper will be oxidised to copper(II) ions.

35. The two chlorine atoms in a molecule of chlorine are held together by

- A non-polar covalent bonding
 B polar covalent bonding
 C hydrogen bonding
 D Van der Waals forces.

36. Which of the following elements is **least** likely to form a chloride?

- A B
 B Si
 C Cs
 D Xe

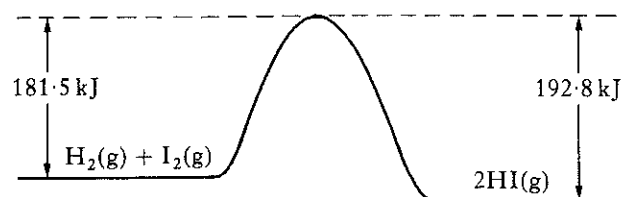
37. An element (m.p. 3500°C) forms a gaseous oxide. Which type of bonding is likely to be present in the element?

- A Metallic
 B Polar covalent
 C Non-polar covalent
 D Ionic

38. As the relative atomic mass in the halogens increases,

- A the ionic radius decreases
 B the density decreases
 C the first ionisation energy increases
 D the boiling point increases.

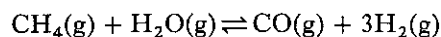
39.



What is the enthalpy (heat) of formation of $2\text{HI}(\text{g})$?

- A $+11.3 \text{ kJ}$
 B -11.3 kJ
 C $+181.5 \text{ kJ}$
 D -181.5 kJ

40. To obtain **hydrogen** in the process below, what would you predict to be the best conditions?



ΔH for forward reaction = $+206 \text{ kJ}$

- A High temperature, low pressure
 B High temperature, high pressure
 C Low temperature, low pressure
 D Low temperature, high pressure

41. Which of the following dissolves in water to form an acidic solution?

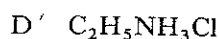
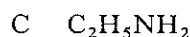
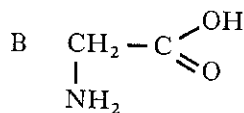
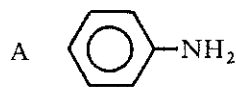
- A Sodium nitrate
 B Barium sulphate
 C Ammonium chloride
 D Potassium ethanoate

42. Which of the following reagents would normally be used to convert ethyne to chloroethene?
- A Chlorine
 - B Hydrogen chloride
 - C Phosphorus pentachloride
 - D Sodium chloride

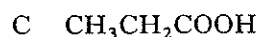
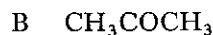
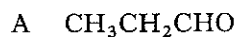
Questions 43 and 44 refer to the following hydrocarbons which all contain six carbon atoms per molecule.

- A Benzene
 - B Hexane
 - C Hex-1-ene
 - D Cyclohexene
43. Which of these compounds has carbon to carbon bonds all of the same length and always gives the same product when one of its hydrogen atoms is replaced by a chlorine atom?
44. Which of these compounds can be synthesised by the addition polymerisation of three molecules of ethyne (acetylene)?
45. Which of the following reactions would be undergone by primary alcohols but not by secondary alcohols?
- A Dehydration to form alkenes
 - B Oxidation to form aldehydes
 - C Esterification
 - D Reaction with sodium to give hydrogen

46. A white crystalline compound, soluble in water, was found to react with both dilute hydrochloric acid and sodium hydroxide solution. Which of the following is it likely to have been?



Questions 47 and 48 refer to compounds with the following formulae.



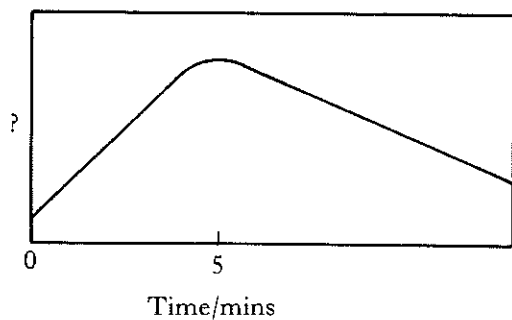
47. Which of the above compounds is formed by the oxidation of propan-2-ol?
48. Which of the above compounds gives a silver mirror with ammoniacal silver nitrate solution (Tollen's reagent)?

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49. During the addition of magnesium granules to an excess of 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 was measured to give the graph below?



[END OF QUESTION PAPER]

50. Which of the following describes the effect of a catalyst?

	<i>Activation energy</i>	<i>Enthalpy (heat) of reaction</i>
A	decreased	decreased
B	decreased	increased
C	unchanged	decreased
D	decreased	unchanged

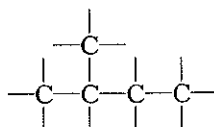
PART A (48 marks)

All questions should be attempted. It should be noted, however, that questions 2 and 6 contain a choice.

It is suggested that about $1\frac{1}{4}$ hours be spent on this part of the paper.

Marks

1. Copy the following carbon skeleton into your answer book **three** times.



Add a hydroxyl group to each skeleton to make

- (a) a primary alkanol;
 - (b) a secondary alkanol;
 - (c) a tertiary alkanol.
- (3)

2. Answer **EITHER A OR B**.

A. Find values for w, x, y and z, such that the following equation will be balanced.



OR

B. Sodium thiosulphate ($\text{Na}_2\text{S}_2\text{O}_3$) decomposes when heated, forming sodium sulphate, sodium sulphide and sulphur. Write a chemical equation for this reaction. (The equation need **not** be balanced.)

(2)

3. (a) An atom loses successively an alpha particle, a beta particle and a gamma ray. What **nett** effect would this have on the parent nucleus? 2
- (b) Both radium oxide (RaO) and radium sulphate (RaSO_4) are radioactive. Compare the intensities of radiation from a 1 g sample of each compound. Explain your answer. 2
- (4)
4. Assume that, during the electrolysis of 250 cm^3 0.1 M copper(II) sulphate solution, all of the copper ions are reduced to copper metal at the negative electrode.
- (a) What quantity of electricity must pass during this reduction? 3
 - (b) Name the gas obtained at the positive electrode. 1
 - (c) Calculate the volume of gas (at s.t.p.) obtained at the positive electrode. 2
- (6)

5. (a) In acid solution, iodate ions, IO_3^- (aq), are readily converted into iodine.
Write an ion–electron equation for this half-reaction. 2
- (b) Use the equation to **explain** whether the iodate ion is an oxidising or reducing agent. 2
(4)

6. Answer **EITHER A OR B**.

- A. Calculate the number of ammonium ions present in 1.32 g of ammonium sulphate.
(Show all your working.) (3)

OR

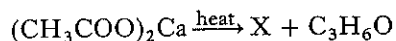
- B. Given 0.25 moles of ammonia gas,
(a) what is the mass of this sample?
(b) how many **atoms** are contained in this sample?
(c) what volume (at s.t.p.) will be occupied by this sample? (3)

7. (a) Use the enthalpies of formation (ΔH_f) in the table below to calculate the enthalpy of combustion of the gas, diborane (B_2H_6).

	$\Delta H_f/\text{kJ mol}^{-1}$
$\text{B}_2\text{H}_6(\text{g})$	+ 32.0
$\text{H}_2\text{O}(\text{l})$	– 286.0
$\text{B}_2\text{O}_3(\text{s})$	– 1225.0

- (b) **Explain** whether ethane or diborane is the better fuel. (Data Booklet, page 10.) 2
(6)

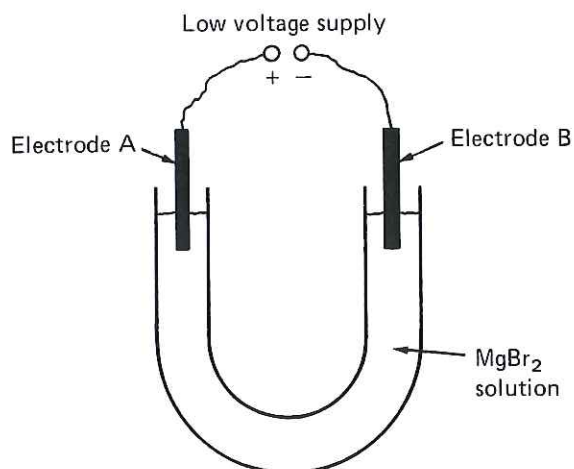
8. When calcium ethanoate is strongly heated, one of the products is an alkanone (ketone):



- (a) Name the substance X. 1
- (b) Name the alkanone $\text{C}_3\text{H}_6\text{O}$. 1
- (c) If this reaction is carried out using a mixture of $(\text{CH}_3\text{COO})_2\text{Ca}$ and $(\text{C}_2\text{H}_5\text{COO})_2\text{Ca}$, one of the products is the alkanone $\text{C}_4\text{H}_8\text{O}$. Draw the extended structural formula of this alkanone. 1
(3)

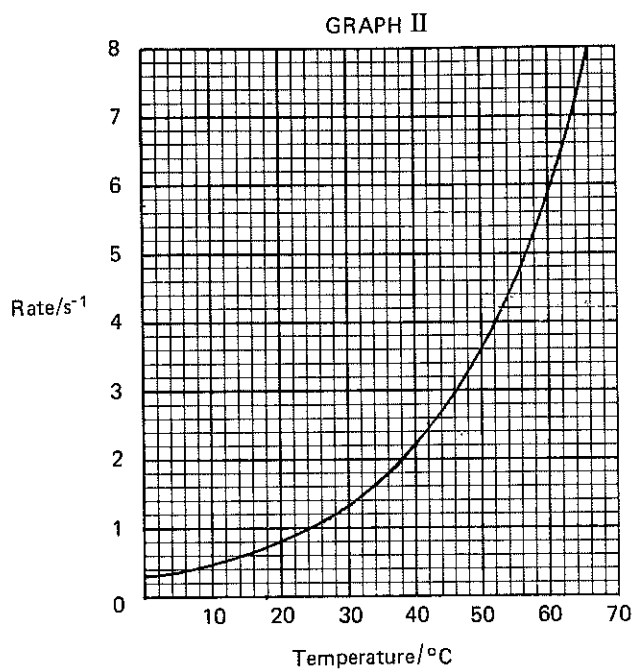
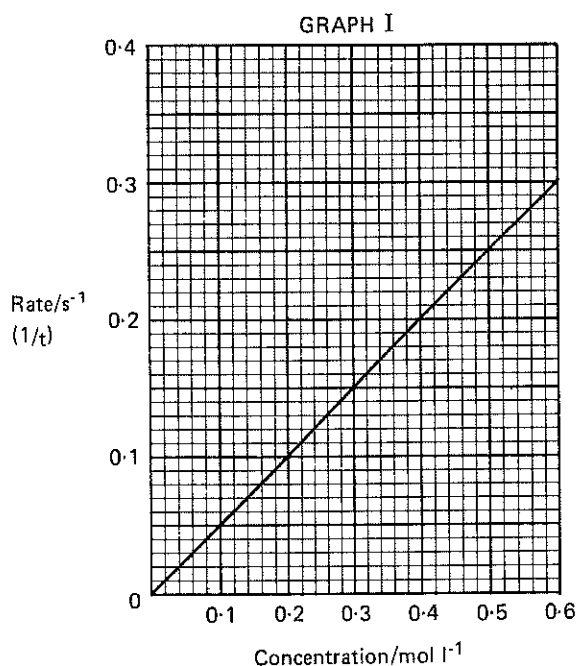
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9. A concentrated aqueous solution of MgBr_2 , containing a little universal indicator, is electrolysed in a U-tube.



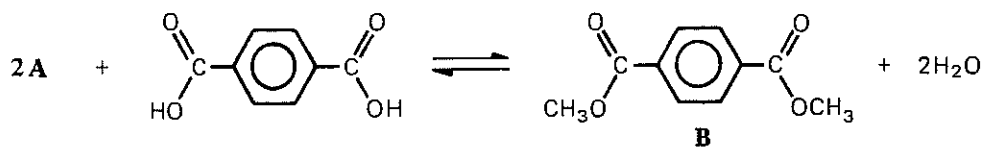
- (a) Name the product obtained at each electrode, A and B. 2
- (b) Write an ion-electron equation for the half-reaction occurring at electrode B. 1
- (c) **Explain** what would happen to the indicator at electrode B. 2
- (5)**
10. A mixture of 80 cm^3 CO and 150 cm^3 O_2 was exploded.
- (a) Write a balanced equation for the reaction. 1
- After cooling, the residual gas was shaken with sodium hydroxide solution.
- (b) Which gas would be absorbed by the sodium hydroxide? 1
- (c) What would be the reduction in volume of the residual gas on shaking with the sodium hydroxide? 1
- (d) What volume of gas would remain? 1
- (Assume all volumes measured at s.t.p.) **(4)**

11. The overall rate of a chemical reaction is often taken as the reciprocal of time (1/time). Graphs of rate of reaction against concentration and rate of reaction against temperature are shown.



- (a) From GRAPH I:
- Calculate the time taken for the reaction when the concentration is 0.4 mol l^{-1} . **2**
 - Explain why the rate increases as the concentration increases. **1**
- (b) From GRAPH II:
- Find the temperature rise required to double the rate of the reaction. **1**
 - Explain why the rate increases very rapidly as the temperature increases. **1**
- (5)**

12. Consider the following reaction:



- Name reactant **A**.
- To which class of substance does product **B** belong?
- Name a reagent which could be used to improve the yield of **B**. **(3)**

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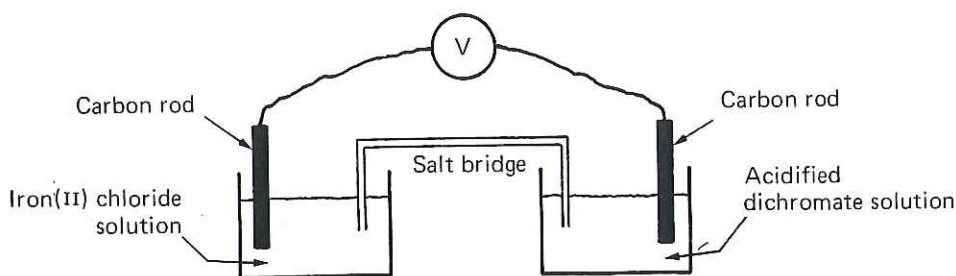
PART B (48 marks)

All four questions should be attempted. It should be noted however that question 16 contains a choice.

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

- | | <i>Marks</i> |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|
| 13. Use the Data Booklet (pages 4 and 5) to answer the questions which follow. | |
| (a) (i) Name the element with the lowest first ionisation energy. | |
| (ii) Why does this element have the lowest value? | |
| (iii) The third ionisation energy for Mg is greater than that for Al. Explain why. | 3 |
| (b) (i) Name a compound formed between two non-metallic elements in which the bonding is likely to be pure covalent (non-polar). | |
| Give a reason for your choice of compound. | 2 |
| (ii) Which pair of elements will be likely to combine to give a compound with most ionic character? | |
| Explain your choice. | 2 |
| (c) Suggest why the ionic radius of the hydride ion (H ⁻) is given in the Data Booklet rather than the ionic radius of the more common positive hydrogen ion (H ⁺). | 1 |
| (d) Write a paragraph accounting for the differences in values in each of the following: | |
| (i) the covalent radii of chlorine and sodium; | |
| (ii) the ionic radii of chlorine and sodium. | 4 |
| | (12) |
|
 | |
| 14. The equation below represents the catalytic oxidation of ammonia. | |
| $4\text{NH}_3(\text{g}) + 5\text{O}_2(\text{g}) \xrightarrow{\text{heat}} 4\text{NO}(\text{g}) + 6\text{H}_2\text{O}(\text{g})$ | |
| (a) (i) Which catalyst is used in this process? | |
| (ii) Why is the catalyst used in the form of a fine wire mesh? | |
| (iii) What would be the products if no catalyst were used? | 3 |
| (b) The catalyst used in this reaction is an example of a heterogeneous catalyst. What is meant here by the term "heterogeneous"? | 1 |
| (c) In a reversible reaction, a catalyst lowers the activation energy of both the forward and reverse reactions. Why then, are catalysts used in industrial reactions involving reversible reactions? | |
| Give two reasons. | 2 |
| (d) Catalysts often undergo a temporary colour change during a reaction. | |
| Give a possible explanation. | 1 |
| (e) Consider the following industrial processes: | |
| Contact Process $2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{SO}_3(\text{g}) \Delta H(\text{forward reaction}) -\text{ve.}$ | |
| Haber Process $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightleftharpoons 2\text{NH}_3(\text{g}) \Delta H(\text{forward reaction}) -\text{ve.}$ | |
| (i) Explain which way the equilibria positions would move with increasing temperature. | 2 |
| (ii) Discuss why the Contact Process uses atmospheric pressure whereas the Haber Process uses pressures in excess of 200 atmospheres. | 3 |
| | (12) |

15. (a) Which reagent would you use to convert iron into
- iron(II) chloride?
 - iron(III) chloride?
- (b) Iron(III) chloride sublimes on heating.
- What is the meaning of the term sublimation?
 - Which type of bonding is implied by the fact that iron(III) chloride sublimes?
- (c)



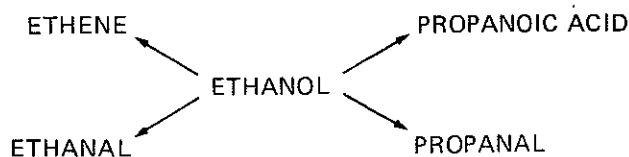
In acid solution, dichromate ions ($\text{Cr}_2\text{O}_7^{2-}(\text{aq})$) are reduced to $\text{Cr}^{3+}(\text{aq})$ ions.

- Calculate the voltage of the cell shown above. (Data Booklet, page 6.)
 - Write a balanced chemical equation for the overall reaction.
 - How many moles of iron(II) ions would be required to react completely with 250 cm^3 0.1 M $\text{Cr}_2\text{O}_7^{2-}(\text{aq})$ solution?
- (d)
- What other reaction might occur if the iron(II) chloride solution were replaced with iron(II) bromide solution?
 - How would you detect the presence of iron(III) ions in a solution?
- (12)

[Turn over

16. Answer EITHER A OR B.

- A. The diagram below shows various compounds to which ethanol may be converted directly or indirectly.



- (a) (i) Name a suitable reagent **and** the type of chemical reaction involved in the conversion of ethanol to ethene. 2
- (ii) Draw a labelled diagram of the apparatus you would use in this reaction. 2
- (b) (i) How would you convert ethanol to ethanal? 1
- (ii) How would you distinguish experimentally between ethanol and ethanal? 2
- (c) Draw the extended structural formula of propanal. 1
- (d) (i) Write a balanced equation for the reaction which occurs between propanoic acid and magnesium. 2
- (ii) Use your equation to calculate the mass of magnesium which reacts with 3.7 g of propanoic acid. 2
- (12)

OR

- B. The detection of carbon and hydrogen in organic compounds may be carried out by heating the compound with dry copper(II) oxide. The water vapour formed is condensed and the carbon dioxide is bubbled through lime water.
- (a) Draw a labelled diagram to show how you would carry out this experiment in the laboratory. 2
- (b) An organic compound X contains 53.3% carbon, 15.6% hydrogen and 31.1% nitrogen. Its molecular mass is 45.
- (i) Calculate the molecular formula of compound X. 3
- (ii) Draw **two** possible extended structural formulae for X and name **one** of them. 3
- (c) Compound X reacts with hydrochloric acid to form a product Y.
- (i) Why is X able to react with hydrochloric acid? 3
- (ii) Write an equation for the reaction occurring in (c)(i) above.
- (iii) What would you expect to happen if product Y were treated with sodium hydroxide? 3
- (d) What would be observed if the original compound X were allowed to react with copper(II) sulphate solution? 1
- (12)

[END OF QUESTION PAPER]