8

Student Number: .....

2001

HIGHER SCHOOL CERTIFICATE

Sample Examination Paper

CHEMISTRY

General Instructions

Reading time - 5 minutes
Working time - 3 hours

- Board approved calculators may be used.
- Write your Student Number on each Answer Book.
- Answer all questions in the spaces provided in the Answer Books. Anything written in the Question Book will NOT be marked.

Section I - Core

- Attempt ALL questions.
- **Part A** 15 multiple -choice questions, each worth 1 mark
  Mark your answers in pencil on the Answer Sheet provided.
- **Part B** Other questions with a total mark value of 60.
  Answer this part in the Part B part of the Answer Book.

Section II - Electives

- Attempt ONE question only.
- Each question is worth 25 marks.
- Answer the question in a separate Elective Answer Booklet.
- You may ask for an extra Elective Answer Book if you need one.

A ***Data Sheet*** and ***Periodic Table*** are provided at the back of this paper.

Directions to School or College

SECTION I - CORE

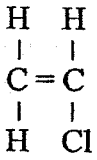
PART A
(15 marks)

Attempt all questions.
Each question is worth 1 mark.
Select the alternative A, B, C or D that best answers the question.
Mark your answers in pencil on the Answer Sheet provided.

1. Emission from radioisotopes can be detected by a

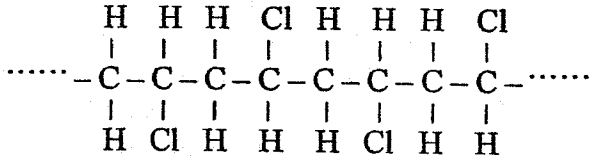
   A. pH meter
   B. thermometer
   C. smoke detector
   D. photographic film

2. PVC (polyvinyl chloride) is an addition polymer made from vinyl chloride (chloroethene)



The most likely structure of a section of PVC is

A.



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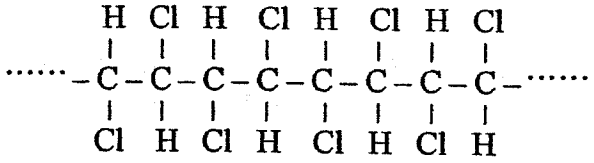

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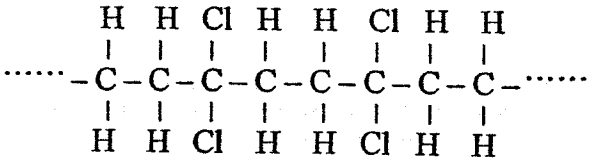

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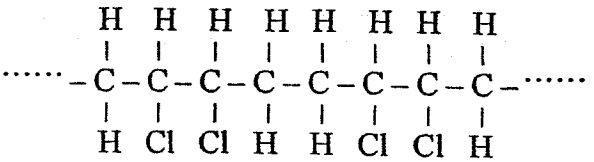


3. The process of catalytic cracking

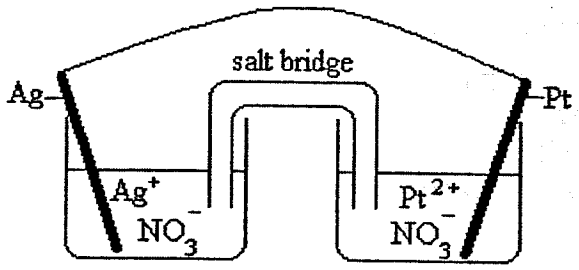
A. changes a long chain alkane to two short chain alkanes.
B. involves reactions on the surface of inorganic catalysts.
C. cracks the solid catalyst to fragments to increase its surface area.
D. is used to convert six-carbon glucose to carbon dioxide and ethanol.

4. When glucose polymerises to form cellulose, the other product formed is

A. water
B. ethanol
C. methane
D. carbon dioxide

5.

	E^o (V)
$Ag^+_{(aq)} + e^- \rightarrow Ag_{(s)}$	0.80
$Pt^{2+}_{(aq)} + e^- \rightarrow Pt_{(s)}$	1.18



In the above galvanic cell electrons flow in the wire from one metal to the other, and anions and cations travel in the salt bridge.

Which set of arrows correctly shows the direction of the movement of the electrons (solid arrow) in the wire and the direction of the movement of the anions (broken arrow) in the salt bridge?

A. → -->
B. → <--
C. ← <--
D. ← -->

6. Which of the following is a dilute strong acid?

A. 5.00 mol L^{-1} HCl
B. 5.00 mol L^{-1} CH_3COOH
C. 0.05 mol L^{-1} HCl
D. 0.05 mol L^{-1} CH_3COOH

7. The table shows the pH of some naturally occurring substances:

substance	approximate pH	substance	approximate pH
stomach acid	2	tomato juice	4
lemon juice	3	sea water	8

The next table shows the properties of four acid-base indicators:

Name	Colour in		pH range in which colour changes
	low pH	high pH	
phenolphthalein	colourless	pink	8.3 – 10.0
phenol red	yellow	red	6.8 – 8.4
methyl red	pink	yellow	4.4 – 6.2
methyl yellow	red	yellow	2.4 – 4.0

Which mixture has the correct colour next to it?

A. lemon juice + phenolphthalein → pink
B. saliva + phenol red → yellow
C. sea water + methyl red → pink
D. stomach acid + methyl yellow → yellow

8. The pHs of 0.2 molar solutions of citric acid, acetic acid and hydrochloric acid are 2.0, 2.7 and 0.7 respectively.

This means that the hydrogen ion concentration of

A. hydrochloric acid is about 100 times that of acetic acid.
B. acetic acid is about 1/3 more than that of citric acid.
C. citric acid is about 3 times that of hydrochloric acid.
D. acetic acid is about ¼ that of hydrochloric acid.

9. In preparing a 0.1 mol L^{-1} primary standard $NaHCO_3$ solution,

A. 0.100 moles of $NaHCO_3$ should be added to 1.000 litre of water.
B. solid $NaHCO_3$ should be dried in the oven before being weighed.
C. the volumetric flask should be rinsed with some 0.1 mol L^{-1} $NaHCO_3$.
D. 100 mL of 0.100 mol L^{-1} solution should be made up to exactly 1.000 L.

10. HCO_3^- is an amphiprotic species as shown by the equations

$$HCO_3^-{}_{(aq)} + HCl_{(aq)} \rightarrow H_2CO_{3(aq)} + Cl^-{}_{(aq)}$$
$$HCO_3^-{}_{(aq)} + OH^-{}_{(aq)} \rightarrow CO_3^{2-}{}_{(aq)} + H_2O_{(l)}$$

The conjugate base of $HCO_3^-{}_{(aq)}$ is

A. OH^-
B. H_2CO_3
C. H_2O
D. CO_3^{2-}

11. The products of the combustion of petrol (mainly octane) are determined partly by the fuel to air ratio and partly by the homogeneity (evenness) of the fuel-air mixture. These products, apart from water, may contribute to global warming, smoky air and a reduction of the oxygen supply to body cells.

Which of the following reactions would cause the greatest amount of smoke?

A. $C_8H_{18} + 7O_2 \rightarrow 9H_2O + 4C + CO_2 + 3CO$
B. $C_8H_{18} + 9O_2 \rightarrow 9H_2O + 3CO + 2C + 3CO_2$
C. $C_8H_{18} + 7O_2 \rightarrow 9H_2O + 5CO + 3C$
D. $C_8H_{18} + 9O_2 \rightarrow 9H_2O + CO_2 + 7CO$

12. Which solution is used to detect the presence of chloride ions?

A. H_2SO_4
B. $Ba(OH)_2$
C. $AgNO_3$
D. NH_3

13. A chief cause of algal bloom in waterways is an increase in the water's

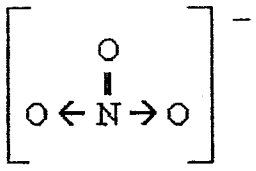
A. acidity
B. hardness
C. temperature
D. phosphate concentration

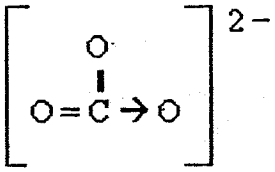
14. I. 2,4-dichloropentane II. 2,4-dichlorohexane
III 2,3-dichlorohexane IV. 2,2,3,3-tetrachloropentane

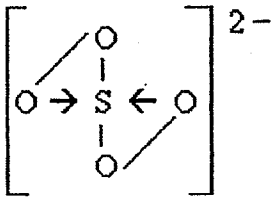
Which two of the above chloroalkanes are isomers?

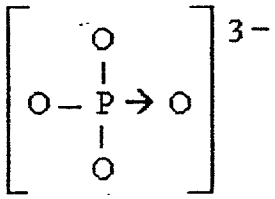
A. I and II
B. I and IV
C. II and III
D. III and IV

15. In which of the following is the coordinate covalent bond correctly indicated by the arrows?

A. 

B. 

C. 

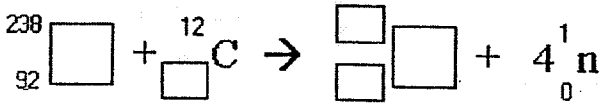
D. 

PART B
(60 marks)

Attempt all questions.
The value of each question is indicated next to the question.
In questions requiring calculations show all working.

Marks

16. Put the appropriate chemical symbol, mass number or atomic number into the boxes to represent a balanced nuclear reaction producing a transuranic element.



2

17. Name a radioisotope used in medicine, and describe what it is used for. **2**

18. Biopolymers are naturally occurring polymers.

    a. Give an example of a biopolymer. **1**

    b. Give two reason for the need to replace polymers made from petroleum products with biopolymers. **2**

19. a. Write equations for the

        i. production of ethanol by fermentation.

        ii. dehydration of ethanol.

        In both cases indicate the catalyst used. **2**

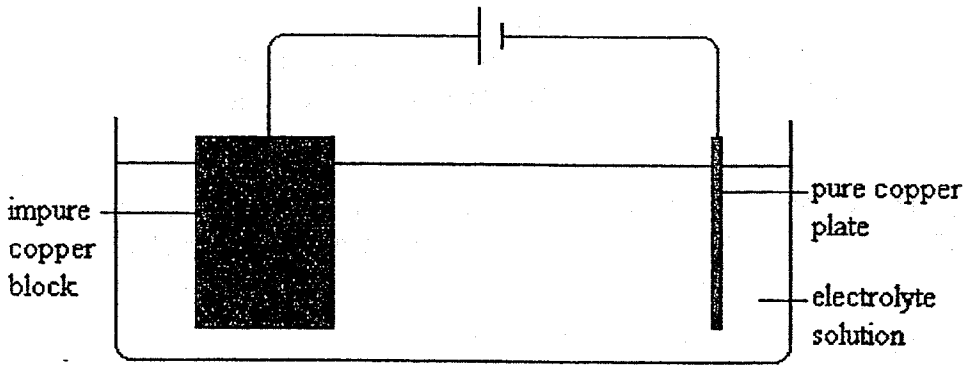
    b. Explain why ethanol is a fairly good solvent for most water soluble compounds. **2**

    c. The table lists some of the properties of octane (the main component of petrol) and of ethanol (which can be used as an alternative to car fuel).

fuel	molar mass (g)	mass of 1 litre (g)	heat released during combustion (kJ mol^{-1})
ethanol	46.1	785	1367
octane	114.2	698	5470

Assuming all other variables to be equal, 1 litre of which fuel would allow a car to travel further? (Calculate the energy obtained by the complete combustion of 1 litre of each of these fuels.) **3**

20. The diagram shows the set-up for the electrolytic refining of copper.



a. Name a suitable electrolyte. 1

b. Write the half equation for the reaction which occurs where this electrolyte is in contact with the pure copper. 1

c. The impure copper acts as the anode in this electrolytic cell. What process takes place at the anode of any cell? 1

21. In water there is an equilibrium between gaseous and dissolved carbon dioxide, according to the equation

$$CO_{2(g)} \rightleftharpoons CO_{2(aq)}$$

The dissolving process is exothermic.

A further series of equilibrium reactions occurs as the dissolved carbon dioxide reacts with water.

$$CO_{2(aq)} + H_2O_{(l)} \rightleftharpoons H_2CO_{3(aq)}$$
$$H_2CO_{3(aq)} + H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + HCO_3^-{}_{(aq)}$$
$$HCO_3^-{}_{(aq)} + H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + CO_3^{2-}{}_{(aq)}$$

Explain in terms of Le Chatelier's Principle why

a. fizzing occurs when a bottle of soft drink is opened? 1

b. the fizzing is less if the bottle of soft drink was kept in the refrigerator than if it was kept at room temperature. 1

c. a "flat" soft drink (i.e. from which all the bubbles escaped) has a higher pH than a newly opened bottle. 1

22. One of the half equations which occurs in a vanadium cell is

$$2H^+ + VO_2^+ + e^- \rightarrow VO^{2+} + H_2O$$

a. Is this an oxidation or a reduction half-equation? Justify your answer. **1**

b. What is the oxidation state of vanadium in VO_2^+? **1**

23. a. To extract metal from sulfide ores, the ore is "roasted" in air. A by-product of the reaction is the poisonous gas sulfur dioxide.

Write the equation for the roasting of the ore copper pyrites (copper (II) sulfide). **1**

b. Calculate the volume of sulfur dioxide gas produced (measured at 101.3 kPa and 25°C) from the roasting of 1 tonne (= 1000 kg = 10^6 g) of copper pyrites. **3**

c. If sulfur dioxide is not removed, it combines with moisture in the air, producing an acid.

Write an equation for the reaction between sulfur dioxide and water. **1**

d. The acid in part (c) can further oxidise, giving acid rain.

Write an equation between acid rain (assume it to be sulfuric acid) and marble statues (assume marble to be calcium carbonate). **1**

24. a. 0.1 mole of propanoic acid was refluxed with 0.1 mole of ethanol and a small amount (1 mL) of concentrated sulfuric acid catalyst.

i. Complete the equation for the reaction

$$CH_3CH_2CH_2COOH_{(l)} + CH_3CH_2OH_{(l)} \rightleftharpoons$$

ii. Name the organic product. **2**

b. Although this is an equilibrium reaction, it was forced to go to completion, so there was no propanoic acid left. To find the amount of sulfuric acid catalyst used, the resultant mixture was titrated with a 0.5 mol L^{-1} sodium hydroxide solution.

i. What was the pH of the sodium hydroxide solution? **1**

ii. It required 68 mL of the sodium hydroxide solution to reach the end point of the titration.

$$H_2SO_{4(aq)} + 2NaOH_{(aq)} \rightarrow 2H_2O_{(l)} + Na_2SO_{4(aq)}$$

How many moles of sulfuric acid were used? **2**

25. a. Explain in words and with equations why

i. HCl is an Arrhenius acid when it dissolves in water. 2

ii. NH_4Cl is a Bronsted-Lowry acid when it reacts with NaOH. 2

b. Draw Lewis diagrams for each of the substances in the following equation

$$BF_3 + NH_3 \rightarrow BF_3NH_3$$

Indicate which species is the Lewis acid. 2

26. The synthesis of ammonia gas is represented by the equation.

$$N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$$

a. Explain why the industrial process uses high pressures but moderate (not too high and not too low) temperatures. 3

b. A catalyst allows this same reaction to proceed at a lower temperature.

i. Name the catalyst which is used in the Haber process of ammonia manufacture.

ii. Explain why the use of the catalyst can lower the temperature that is needed for this reaction. 3

27. The nitrogen content of a fertiliser was determined by heating 0.95 g of the finely ground fertiliser with 100.0 mL of 0.15 mol L^{-1} of sodium hydroxide solution, known to be in excess. This converted all the ammonium ions in the fertiliser to ammonia gas, which left the mixture.

$$NH_4^+{}_{(aq)} + OH^-{}_{(aq)} \rightarrow NH_{3(g)} + H_2O_{(l)}$$

The sodium hydroxide left over after the reaction stopped needed 23.1 mL of 0.23 mol L^{-1} hydrochloric acid for neutralisation.

$$NaOH_{(aq)} + HCl_{(aq)} \rightarrow H_2O_{(l)} + NaCl_{(aq)}$$

a. How many moles of sodium hydroxide reacted with the ammonium ions? 3

b. How many moles of nitrogen were in 0.95 g of fertiliser? (Assume that all the nitrogen in the fertiliser is present as ammonium ions.) 1

c. What was the percentage of nitrogen, by mass, in the fertiliser? 2

29. Explain why it is dangerous to

a. decrease the concentration of ozone in the upper atmosphere (stratosphere). 1

b. increase the concentration of ozone in the lower atmosphere (troposphere). 1

30. The river water downstream from a factory was suspected of having lead ion and barium ion contamination.

a. Analysis of a sample of this water by atomic absorption spectroscopy found its absorbance value at the main lead wavelength to be 0.078. The absorbance value of a standard laboratory sample, known to have a concentration of 5.85 ppm (parts per million) of lead, was 1.087.

Calculate the concentration of lead, in ppm, in the river water sample. (Note: absorbance is proportional to concentration.) 1

b. A 100.0 mL sample of the river water was mixed with 10.0 mL of 2.05 mol L^{-1} sulfuric acid. The precipitate that formed was filtered, dried and weighed. Its mass was 0.27 g.

$$Ba^{2+}_{(aq)} + SO_4^{2-}_{(aq)} \rightarrow BaSO_{4(s)}$$

i. How many moles of barium sulfate precipitated?

ii. How can you be sure that there was enough sulfuric acid used?

iii. What was the mass of barium (ions) per litre of river water? 3

OPTION 2. SHIPWRECKS AND SALVAGE

Marks

1. Identify the people associated with the following:

   a. The generation of electricity by creating a circuit of two dissimilar metals and a fresh frog muscle. **1**

   b. The first scientific use of electricity to decompose compounds. (The first person to prepare samples of potassium and sodium.) **1**

   c. The discovery that the mass of a substance formed at an electrode during electrolysis is proportional to the quantity of electricity that passes through the electrolytic cell. **1**

2. Although aluminium is a much more reactive metal than iron, aluminium objects do not deteriorate readily.

   Explain why aluminium objects resist deterioration. **1**

3. Below are the reduction potentials of some standard half cells:

	E^o (V)
$Mg^{2+} + 2e^- \rightleftharpoons Mg_{(s)}$	–2.35
$2H_2O_{(l)} + 2e^- \rightleftharpoons H_{2(g)} + 2OH^-$	–0.83
$Pb^{2+} + 2e^- \rightleftharpoons Pb_{(s)}$	–0.13
$Cu^{2+} + 2e^- \rightleftharpoons Cu_{(s)}$	0.34
$I_{2(aq)} + 2e^- \rightleftharpoons 2I^-$	0.54
$O_{2(g)} + 4H^+ + 4e^- \rightleftharpoons 2H_2O_{(l)}$	1.23
$Cl_{2(aq)} + 2e^- \rightleftharpoons 2Cl^-$	1.36

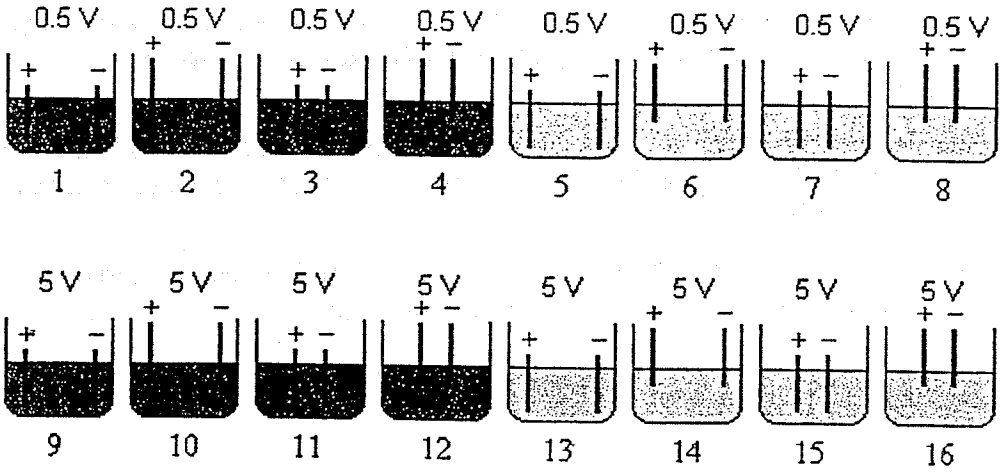
   a. What is the voltage of a standard $Cu / Cu^{2+} \| Pb^{2+} / Pb$ cell? **1**

   b. What will be discharged initially at the anode and at the cathode when 0.1 mol L^{-1} solutions of the following compounds are electrolysed?

      i. copper (II) iodide

      ii. magnesium chloride **2**

4. In which container will the rate of electrolysis of the same electrolyte be the fastest?



Key:

0.1 mol L^{-1}

1.0 mol L^{-1}

1

5. a. Explain with the help of a labelled diagram how the hull of a steel ship is protected by a "sacrificial anode" (cathodic protection). **4**

   b. Apart from ships, where is cathodic protection used? **1**

   c. i. Identify another way of preventing rust formation.

   ii. Explain how this method prevents rusting. **2**

6. a. What are anaerobic bacteria? **1**

   b. How do anaerobic bacteria speed up the corrosion of deep sea shipwrecks? **2**

7. Sketch graphs to show the relationship between

   a. the solubility of salts as a function of water temperature. **1**

   b. the solubility of gases as a function of water temperature. **1**

   c. the solubility of gases as a function of water depth. **1**

8. a. Why is the simple drying of soaked leather and wood artefacts recovered from shipwrecks a bad practice? 1

b. i. Write the neutral species equation for the reaction between silver coins (sunk with a ship) and hydrogen sulfide (produced by anaerobic bacteria).

ii. Write the reduction half equation for the restoration of these silver coins by electrolysis, using the silver sulfide covered coins (one at a time) as the cathode.

iii. Write the ionic equation for the process by which limestone and coral encrusted copper artefacts are chemically cleaned. 3