IONA PRESENTATION COLLEGE

Year 12 Chemistry

Semester Two Examination, 2000

Student Name : _____

TIME ALLOWED FOR THIS PAPER

Reading time before commencing work: Ten minutes
Working time for paper: Three hours

MATERIAL REQUIRED/RECOMMENDED FOR THIS PAPER

TO BE PROVIDED BY THE SUPERVISOR

This Question Paper/Answer Booklet
Separate Multiple Choice Answer Sheet
Chemistry/Data Sheet (inside front cover of this Question/Answer booklet)

TO BE PROVIDED BY THE CANDIDATE

Standard Items: Pens, pencils, eraser or correction fluid, ruler
Special Items: Calculators satisfying the conditions set by the Curriculum Council and a 2B, B or HB pencil for the separate Multiple Choice Answer Sheet.

IMPORTANT NOTE TO CANDIDATES

It is your responsibility to ensure that you do not have any unauthorised notes or other items of a non-personal nature in the examination room. If you have any unauthorised material with you, hand it to the supervisor BEFORE reading any further.

STRUCTURE OF THIS PAPER

Part	Format	No. of Questions Set	No. of Questions to be Attempted	Marks Allocated	Recommended Time (Approx) /Minutes
1.	Multiple choice	30	ALL	60 (30%)	55
2.	Short answers	11	ALL	70 (35%)	60
3.	Calculations	5	ALL	50 (25%)	45
4.	Extended answers	3	1	20 (10%)	20

Total marks for paper = 200 (100%)

INSTRUCTIONS TO CANDIDATES

Reading Time: The examiners recommend that candidates spend the reading time mainly reading the Instructions to Candidates and Parts 2, 3 and 4.

Part 1 — Multiple Choice

Use a 2B, B or HB pencil to answer on the separate Multiple Choice Answer Sheet. **Do not** use a ballpoint or ink pen.

If you consider that two or more of the alternative responses are correct, choose the one you think is best. If you think you know an answer, mark it even if you are not certain you are correct. Marks will **not** be deducted for incorrect answers.

FEEL FREE TO WRITE OR DO WORKING ON THE QUESTION PAPER; many students who score high marks in the Multiple Choice Section do this.

Parts 2, 3 and 4

Use a ballpoint or ink pen. **Do not** answer in pencil. Write your answers in this Question/Answer Booklet.

At the end of the examination make sure that your Student Number is on your Question/Answer booklet and on your separate Multiple Choice Answer Sheet.

Questions containing specific instructions to show working should be answered with a complete, logical, clear sequence of reasoning showing how the final answer was arrived at; correct answers which do not show working will not be awarded full marks.

CHEMICAL EQUATIONS

For full marks, chemical equations should refer only to those species consumed in the reaction and the new species produced. These species may be **ions** [for example Ag^{+}(aq], **molecules** [for example NH_3,(g), NH_3(aq), $CH_3COOH(l)$, CH_3COOH(aq)] or **solids** [for example $BaSO_4$(s), Cu(s), Na_2CO_3(s)].

SEE NEXT PAGE

PART 1 : MULTIPLE CHOICE

1. The energies to remove electrons in succession from the neutral atom or an ion of a certain element, A, are given below

REACTION	**ENERGY (kJ mol^{-1})**
to form A^{+} from A	1012
to form A^{2+} from A^{+}	1903
to form A^{3+} from A^{2+}	2912
to form A^{4+} from A^{3+}	4957
to form A^{5+} from A^{4+}	6274
to form A^{6+} from A^{5+}	21269
to form A^{7+} from A^{6+}	25398
to form A^{8+} from A^{7+}	29855

Element A is likely to be

A. Nitrogen
B. Oxygen
C. Chlorine
D. Phosphorus

2. Fluorine, chlorine, bromine and iodine show many similarities in their chemical behaviour. The most fundamental reason for this is that

A. they all form hydrides of the general formula HX.
B. they are all coloured non-metallic elements, with steadily increasing melting temperatures.
C. all their outer shell electrons in their ground state are in the same shell.
D. they all have the same outer shell electronic configuration.

3. Which one of the following elements exhibits the highest positive oxidation number in its compounds?

A. oxygen
B. sulfur
C. nitrogen
D. phosphorus.

4. Which one of the following groups of substances consists only of compounds containing covalent bonds?

A. Methanol, butane, sodium chloride, diamond.
B. Benzene, carbon monoxide, methane, nitrogen.
C. Water, chlorobenzene, ethylene, silver chloride.
D. Sulfur dioxide, carbon dioxide, nitrogen oxide, iron(III) oxide.

SEE NEXT PAGE

5. Lead nitrate , $Pb(NO_3)_2$, is a white crystalline solid made up of the ions, Pb^{2+} and NO_3^-. When lead nitrate dissolves in water , the solution contains

A. equal numbers of lead and nitrate ions.
B. twice as many nitrate ions as lead ions.
C. three times as many nitrate ions as lead ions.
D. six times as many nitrate ions as lead ions.

6. The complete combustion of octane in a car engine is best described by the equation

A. $C_8H_{18}(g) + O_2(g) = CO_2(g) + H_2O(g)$
B. $C_8H_{18}(g) + 17O_2(g) = 8CO_2(g) + 18H_2O(g)$
C. $2C_8H_{18}(g) + 34O_2(g) = 16CO_2(g) + 18H_2O(g)$
D. $2C_8H_{18}(g) + 25O_2(g) = 16CO_2(g) + 18H_2O(g)$

7. Of the following, the compound with the SMALLEST percentage by mass of nitrogen is

A. NH_4NO_3
B. $(NH_4)_2SO_4$
C. $NaNO_3$
D. NH_3

8. If the relative atomic mass of an element is 20.00 and it consists of two naturally occurring isotopes, one of which has a percentage abundance of 75.00% and a relative isotopic mass of 20.50, the relative isotopic mass of the other isotope is

A. 18.50
B. 18.40
C. 18.30
D. 18.20

9. The following statements (A-D) refer to equal masses of two different gases confined to equal volumes at the same temperature. Which ONE of these statements is definitely true?

A. The gas with the higher density will exert the greater pressure.
B. The two gases will exert the same pressure.
C. The gas with the higher molecular weight will exert the greater pressure.
D. The gas with the lower molecular weight will exert the greater pressure.

10. A flask containing a gas of relative molecular mass 112 is weighed and then is evacuated. It is filled with nitrogen at the same temperature and pressure and is again weighed. The mass of the original gas is approximately

A. one quarter that of nitrogen.
B. the same as that of nitrogen.
C. four times that of nitrogen.
D. eight times that of nitrogen.

SEE NEXT PAGE

11. 1 L of HCl solution, which has pH 3, is diluted to 100 L. The pH of the diluted solution would be about

A. 0.03.
B. 1.
C. 4.
D. 5.

12. Which one of the following is a conjugate acid-base pair?

A. HNO_3 and HNO_2
B. NH_3 and OH^-
C. HNO_3 and H_2O
D. H_2O and OH^-

13. The AVERAGE oxidation number of carbon in sucrose, $C_{12}H_{22}O_{11}$, is

A. -1.
B. 0.
C. +1.
D. +2.

14. Nitrifying and denitrifying bacteria have important roles in the nitrogen cycle. They are involved in the following reactions.

Reaction I $NH_4^+(aq) \xrightarrow[\text{bacteria}]{\text{nitrifying}} NO_3^-(aq)$

Reaction II $NO_3^-(aq) \xrightarrow[\text{bacteria}]{\text{denitrifying}} N_2(g)$

Which one of the following statements is true?

A. Reaction I is an acid-base reaction while reaction II is a oxidation reaction.
B. Reaction I and reaction II are both acid-base reactions.
C. Reaction I and reaction II are both oxidation reactions.
D. Reaction I is an oxidation reaction while reaction II is a reduction reaction.

15. Gaseous H_2 and I_2 are added to gaseous HI. When equilibrium is reached, the value of the equilibrium constant, K_c, will depend on

A. the initial concentration of HI.
B. the total pressure of the system.
C. the volume of the reaction vessel.
D. the temperature of the system.

SEE NEXT PAGE

16. 1×10^{20} molecules of HI were introduced into a vessel of fixed volume at a particular temperature. After some time, there were 6×10^{19} molecules of HI, 2×10^{19} molecules of H_2 and 2×10^{19} molecules of I_2 in the vessel. The temperature was unchanged, and at this temperature, the value of the equilibrium constant for the reaction:

$2HI \Leftrightarrow H_2 + I_2$, is $K_c = 2.0$.

Which one of the following statements about the system is correct?

A. The system is at equilibrium.
B. The system is NOT at equilibrium.
C. It is impossible to decide whether the system is at equilibrium or not, as the temperature was not stated.
D. It is impossible to decide whether the system is at equilibrium or not, as K_c refers to concentrations expressed in mol L^{-1}, and the volume of the vessel was not stated.

17. At temperatures above 160^oC, nitrogen dioxide dissociates according to the equation:

$2NO_2(g) \Leftrightarrow 2NO(g) + O_2(g) \qquad \Delta H = +181 \text{ kJ mol}^{-1}$

If a mixture of NO_2, NO and O_2 at equilibrium at 500^oC is cooled to 300^oC at constant volume, then when equilibrium is re-established

A. the concentration of NO has decreased.
B. the concentration of NO_2 has decreased.
C. the equilibrium constant has increased.
D. the equilibrium constant remains unchanged.

18. In which one of the following solids would you expect hydrogen bonding to play a significant role in determining the melting temperature?

A. $H_2(s)$
B. $C_2H_6(s)$
C. $(NH_2)_2CO(s)$
D. $CH_3Br(s)$

19. Consider an exothermic reaction summarised as REACTANTS → PRODUCTS. There is an energy difference between the reactant and product molecules. Which one of the following best summarises the main source of this energy difference between the reactants and the products?

A. Kinetic energy is converted into chemical bond energy.
B. Kinetic energy is converted into kinetic energy.
C. Chemical bond energy is converted into kinetic energy.
D. Chemical bond energy is converted into chemical bond energy.

SEE NEXT PAGE

20. Energy is released when hydrogen burns in oxygen because

A. the net strength of the chemical bonds within the reactant molecules is greater than the net strength of the chemical bonds within the product molecules.
B. the net strength of the chemical bonds within the reactant molecules is less than the net strength of the chemical bonds within the product molecules.
C. there are fewer product molecules than there are reactant molecules.
D. the reactants are elements while the product is a compound.

21. Consider the following information.

$Ce^{4+}(aq) + e^- = Ce^{3+}(aq)$ $E^0 = +1.443$ V
$Sn^{4+}(aq) + 2e^- = Sn^{2+}(aq)$ $E^0 = +0.150$ V
$X^+(aq) + e^- = X(s)$ $E^0 = E_X$

If metal X(s) is oxidised to $X^+(aq)$ by 1 mol L^{-1} solutions of $Ce^{4+}(aq)$ and by 1 mol L^{-1} solutions of $Sn^{4+}(aq)$, but not by 1 mol L^{-1} of $H^+(aq)$ solutions, the value of E_X must be

A. less than zero volt.
B. between zero volt and 0.150 volt.
C. between 0.150 volt and 1.443 volt.
D. greater than 1.443 volt.

QUESTIONS 22 AND 23 REFER TO THE FOLLOWING INFORMATION.
The cell reaction occurring in a particular galvanic cell as current is drawn is:
$Ag_2O(s) + Zn(s) + H_2O(l) = 2Ag(s) + Zn(OH)_2(s)$.
The cell potential is +1.50 V.

22. In the galvanic cell referred to above, zinc forms

A. the positive electrode, and is reduced.
B. the positive electrode, and is oxidised.
C. the negative electrode, and is reduced.
D. the negative electrode, and is oxidised.

23. Given that the electrolyte in the cell is a 1 mol L^{-1} KOH aqueous solution and that the silver/silver oxide electrode in alkaline solution has an E^0 value of +0.34 V, then the E^0 of the zinc/zinc hydroxide electrode in alkaline solution is

A. -1.16 V.
B. -1.84 V
C. +1.16 V
D. +1.84 V

24. A steady current is passed for a fixed time through three cells connected in series containing respectively the aqueous solutions 1 mol L^{-1} $CuSO_4$, 1 mol L^{-1} $AgNO_3$ and 1 mol L^{-1} $AlCl_3$. Each of the cells has two platinum electrodes. The molar ratio n(Cu) : n(Ag) : n(Al) of metal deposited at the negative electrode in each cell is

A. 2 : 1 : 0
B. 2 : 1 : 3
C. 2 : 3 : 1
D. 1 : 2 : 0

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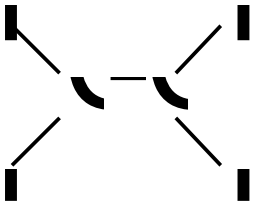
25. Polytetrafluoroethene is formed from the monomer, tetrafluoroethene, which has the structural formula



The empirical formula of polytetrafluoroethene is

A. CF
B. CF_2
C. C_2F
D. C_2F_4

26. Benzoic acid, C_6H_5COOH, may be readily formed when a particular compound is heated with acidified potassium dichromate solution. The compound is probably

A. C_6H_5CHO
B. $C_6H_5CH_3$
C. C_6H_5OH
D. $C_6H_5COCH_3$

27. When normal butane is chlorinated, the number of dichloro isomers possible is

A. 4
B. 5
C. 6
D. 7

28. Which of the following reactions is an example of a substitution reaction?

A. $C_3H_6 + HCl \rightarrow C_3H_7Cl$
B. $CH_3COOH + H_2O \rightarrow CH_3COO^- + H_3O^+$
C. $2C_6H_6 + 15O_2 \rightarrow 12CO_2 + 6H_2O$
D. $C_2H_5Cl + Cl_2 \rightarrow C_2H_4Cl_2 + HCl$

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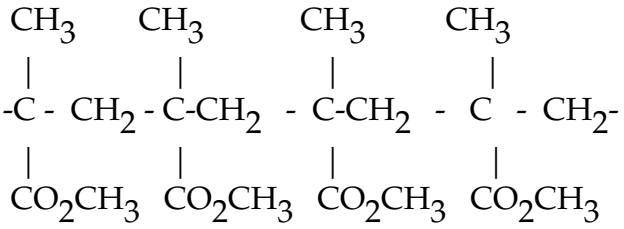
29. Part of the structure of the polymer poly(methylmethacrylate), commonly known as Perspex, is represented below.



The chemical structure of the monomer unit producing this polymer is

A. $CH_3 - CH(CH_3)(CO_2CH_3)$
B. $CH_3 = CH(CH_3)(CO_2CH_3)$
C. $CH_2 = C(CH_3)(CO_2CH_3)$
D. $CH_2 - CH(CH_3)(CO_2CH_3)$

30. In which one of the following does geometrical (cis-trans) isomerism exist?

A. $CH_2=CH-CH_2Cl$
B. $(CH_3)_2C=CH-CH_3$
C. $CH_3-CH_2-CH=CHCl$
D. $ClCH_2-CH_2Cl$

END OF PART 1

PART 2 : SHORT ANSWERS

Answer **ALL** questions in Part 2 in the spaces provided below.
This part carries **70 marks**.

1. Give fully balanced equations for the reactions which occur in the following experiments. Use ionic equations where appropriate. In each case describe observations such as colour changes, precipitate formation (give the colour), or gas evolution resulting from the chemical reaction.

   (a) 1 mol L^{-1} silver nitrate solution is added to 1 mol L^{-1} sodium chloride solution. **(3 marks)**

   Equation:

   Observation:

   (b) A piece of sodium metal is added to some methanol. **(3 marks)**

   Equation:

   Observation:

   (c) Solid calcium carbonate is added to 5 mol L^{-1} hydrochloric acid. **(3 marks)**

   Equation:

   Observation:

   (d) Zinc metal is added to Iron (III) sulfate solution. **(3 marks)**

   Equation:

   Observation:

SEE NEXT PAGE

2. In each of the following reactions, state whether the first named chemical is acting as an ACID, a BASE or NEITHER. Give a reason for your answer in each case. **(4 marks)**

(i) $H_2O(l) + NH_3(aq) = NH_4^+(aq) + OH^-(aq)$

Answer _____

_____

_____

(ii) $2Na(s) + 2H_2O(l) = 2NaOH(aq) + H_2(g)$

Answer _____

_____

_____

(iii) $HPO_4^{2-}(aq) + H_2O(l) = H_2PO_4^-(aq) + OH^-(aq)$

Answer _____

_____

_____

(iv) $Zn(s) + 2H^+(aq) = Zn^{2+}(aq) + H_2(g)$

Answer _____

_____

_____

SEE NEXT PAGE

3. For each molecule listed in the table below

(i) draw the structured formula,
representing **all** valence shell electon pairs either as **:** or as —

(for example, water $H : \ddot{O} : H$ **or** $H - \underline{\overline{O}} - H$) **or** $H - \ddot{O} - H$ and so on)

(ii) indicate the shape of each molecule by either a sketch **or** a name.

Molecule	Structural formula	Shape (sketch or name)
methanal		
methane		
carbon dioxide		

(9 marks)

4. Write the systematic (IUPAC) name of each of the following:

(a) $O = C(H) - CH_2 - CH_2 - CH(CH_2 - CH_3) - CH_3$

Name _____

(b) $CH_3 - CH(CH_3) - CH_2 - C(CH_3)_2 - CH_3$

Name _____

(4 marks)

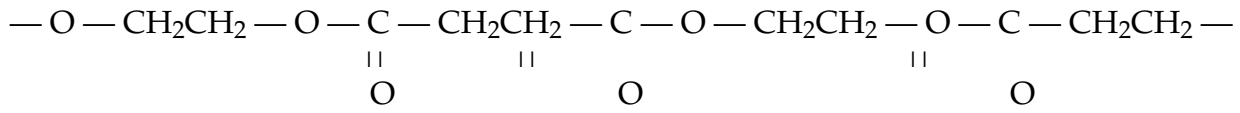
SEE NEXT PAGE

5. Give a chemical test which would distinguish between cyclohexane and cyclohexene. State the observations you would expect to make, and give the equation for any reaction.

Test
Observation
Equation

(4 marks)

6. The following diagram shows part of a polymer molecule



(a) Draw structural formulae for the two monomer molecules which combine to form the polymer.

(3 marks)

(b) Name the type of polymerisation process involved. _____

(1 mark)

(c) Give the formula of the substance which is produced in the polymerisation, besides the polymer.

(1 mark)

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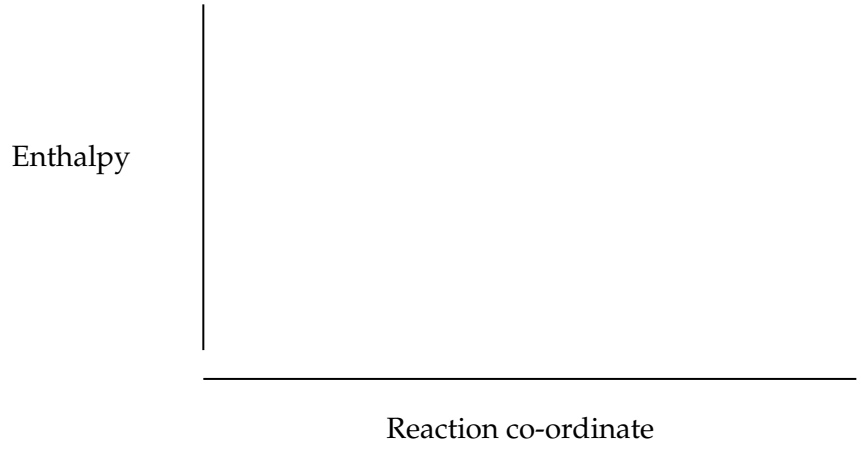
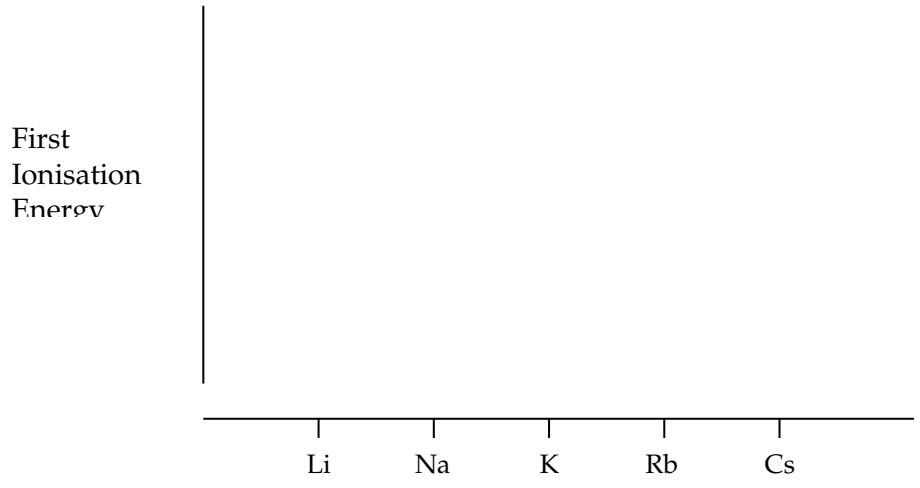
7. Using the axes provided make a simple sketch of the following:

(a) The potential energy diagram for an endothermic reaction with a significant activation energy.



(2 marks)

(b) The first ionization energies of the following alkali metals.



(2 marks)

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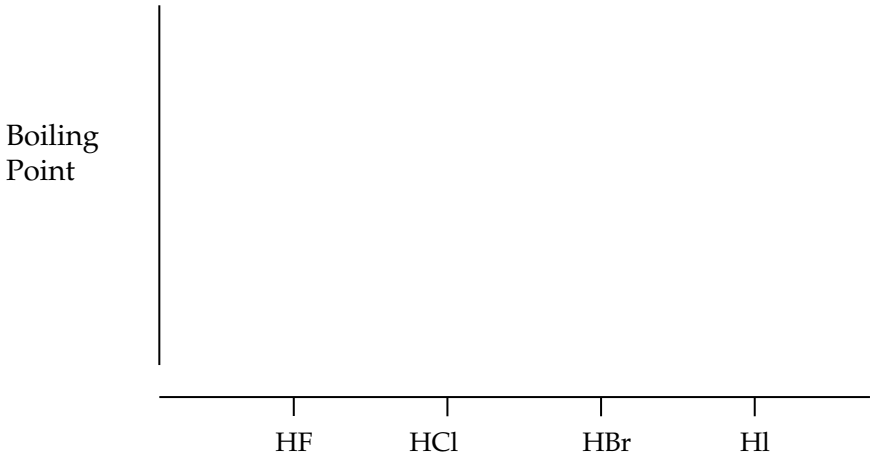
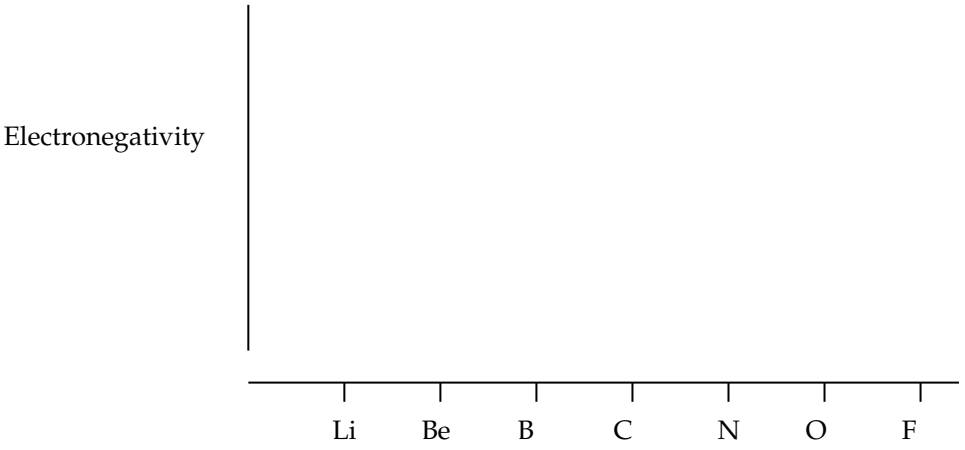
7. (c) The boiling points of the hydrides of the group VII elements.



(2 marks)

(d) The electronegativities of the second period elements.



(2 marks)

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8.

Above is a diagram of an electrochemical cell.

(a) Write a chemical equation to show the reaction at the anode of the cell.

_____

(2 marks)

(b) Draw an arrow on the diagram to indicate the flow of electrons in the external circuit.

(1 mark)

(c) Give the formula one ion that will move from the copper half cell towards the nickel half cell in the salt bridge?

_____

(1 mark)

(d) Under standard conditions, what would be the maximum reading on the voltmeter?

_____

(2 marks)

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9. This question is about the synthesis of ammonia from its elements as represented by the equation:

$$N_2(g) + 3H_2(g) == 2NH_3(g) \qquad \Delta H = -97 \text{ kJ}$$

and the synthesis of nitrogen (II) oxide from its elements:

$$N_2(g) + O_2(g) == 2NO(g) \qquad \Delta H = +180 \text{ kJ}$$

(a) Explain why ammonia is synthesised under the highest practically attainable pressure, while nitrogen (II) oxide is synthesised at about atmospheric pressure.

_____

_____

_____

(2 marks)

(b) Explain why, when ammonia is synthesised, the reactants are heated to about 500˚C.

_____

_____

_____

(2 marks)

(c) Explain why nitrogen (II) oxide is synthesised at the highest practically attainable temperature (3000˚C - 3500˚C).

_____

_____

_____

(2 marks)

SEE NEXT PAGE

10. (a) The pH of a 0.1 mol L^{-1} $NaHCO_3$ solution is 8.3. With the help of one or more suitable chemical equations explain why the pH is greater than 7.

(b) The pH of a 0.1 mol L^{-1} $NaHSO_4$ solution is 1.2. With the help of one or more suitable chemical equations explain why the pH is less than 7.

(6 marks)

SEE NEXT PAGE

11. Hydriodic acid (HI), like hydrochloric acid, is a strong acid. When a few crystals of white xenon trioxide (XeO_3) are added to a hydriodic acid solution, a vigorous reaction occurs and the solution turns brown while an inert gas (which must be xenon) bubbles off. Work out the equation for the reaction that has occurred.

Write the equation for the reduction half-reaction
Work out the equation for the oxidation half-reaction
Give the equation for the redox reaction

(6 marks)

END OF PART 2

PART 3 : CALCULATIONS

Answer ALL questions in Part 3. The calculations are to be set out in detail in this Question/Answer Booklet. Marks will be allocated for correct equations and clear setting out, even if you cannot complete the problem. When questions are divided into sections, working for each section must be clearly distinguished using (a), (b), and so on. You **MUST** correct final numerical answers to three (3) significant figures where appropriate, and you **MUST** provide units where applicable. Information which may be necessary for solving the problems is located on the separate Chemistry Data Sheet. You **MUST** show clear reasoning, and failure to do so will result in loss of marks. This part carries 50 marks (25% of the total).

1. The hardness of a bore water sample was determined by analysis for calcium. An excess of sodium oxalate [sodium ethanedioate—$Na_2C_2O_4$ or $Na_2(O_2CCO_2)$], was added to 1.000 L of the bore water, and the pH adjusted with ammonia to ensure complete precipitation of the calcium ions as calcium oxalate.

   The resulting slurry was filtered, the precipitate washed, and the oxalate ion was brought into solution as oxalic acid [HOOCCOOH], using dilute sulfuric acid.

   This solution was titrated with potassium permanganate solution, and required 10.20 mL of 0.1000 mol L^{-1} permanganate before the first faint permanent pink colour indicated an end-point.

   (a) Use half-equations from your table of standard reduction potentials to write a balanced equation for the reaction of permanganate ion with oxalic acid in acid solution, and state how many moles of oxalic acid are oxidised by 1 mole of permanganate.

   (3 marks)

   (b) Calculate the number of moles of oxalic acid oxidised in the titration with 10.20 mL of 0.1000 mol L^{-1} permanganate.

   (2 marks)

   (c) Hardness in water is expressed as a number of "degrees of hardness" where a degree of hardness is defined as the equivalent of 1 mg of $CaCO_3$ in solution in 1 L of the hard water.

   Use the answer to (b) to state the number of moles of Ca^{2+} in 1.000 L of the hard water. Hence calculate the number of mg of $CaCO_3$ corresponding to this amount of Ca^{2+}.

   (5 marks)

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2. A sample of brass (consisting only of copper and zinc) is dissolved in concentrated nitric acid and the volume made up to 500.0 mL with distilled water.

200.0 mL of this solution is treated with an excess of sodium hydroxide solution to neutralise the excess nitric acid and to precipitate all the copper(II) ion and to convert all the zinc ion into $Zn(OH)4^{2-}$. The mixture is filtered and the residue washed with distilled water. The residue is then mixed with 100 mL of distilled water and boiled until all the residue is converted to copper(II) oxide. The oxide is collected by filtration, washed with distilled water and dried. The mass of copper(II) oxide is found to be 3.005 g.

A further 200.0 mL of the original solution is treated with an excess of sodium carbonate solution to neutralise the excess nitric acid and to precipitate all the copper(II) ion and zinc ion. The resulting mixture is filtered and the precipitate washed, dried and heated strongly to convert it into a mixture of copper(II) oxide and zinc oxide. The mass of this solid is 4.996 g.

(a) Calculate the mass of copper in the sample.

(5 marks)

(b) Calculate the percentage by mass of zinc in the sample.

(7 marks)

_____

_____

_____

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3.

In the above electrolysis cell the electrodes in the left hand cell are silver and the electrolyte 0.1 mol L^{-1} silver nitrate. The electrodes in the right hand cell are made from a metal X and the electrolyte is 0.1 mol L^{-1} solution of the nitrate of X.

In an experiment 0.3052 g of silver is deposited on the cathode in the left hand cell when 0.0830 g of X is deposited on the cathode in the right hand cell.

In a separate experiment a sample of the metal X is treated with hot carbon monoxide to form the gaseous compound $X(CO)_4$. 5.58 g of this compound is found to occupy 1 L at 100°C and 1.00 atm pressure.

(a) Determine the relative atomic mass (atomic weight) of X.

(5 marks)

(b) Calculate the valence of the metal X in the nitrate of X used in the first experiment.

(5 marks)

_____

_____

_____

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4. A naturally occurring organic compound is known to contain the elements hydrogen, carbon, nitrogen and oxygen. To determine its empirical formula, 4.50 g of the organic compound was completely burnt in oxygen to produce 2.70 g of liquid water and 3.36 L of a gaseous mixture containing only nitrogen and carbon dioxide only. The gas mixture was then reacted with a concentrated solution of sodium hydroxide which absorbs all the carbon dioxide. 2.69 L of the gas was absorbed leaving 0.67 L of nitrogen gas unreacted. All gas volumes are given at STP.

   (a) Calculate the mass of hydrogen present in 4.50 g of the organic compound
   (2 marks)

   (b) Calculate the mass of carbon present in 4.50 g of the organic compound.
   (2 marks)

   (c) Calculate the mass of nitrogen present in 4.50 g of the organic compound.
   (2 marks)

   (d) Calculate the mass of oxygen present in 4.50 g of the organic compound.
   (2 marks)

   (e) Determine the empirical formula of the organic compound.
   (2 marks)

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5. Cerium(IV) ion is an important industrial oxidising agent, but no cerium(IV) compound is a primary standard. Cerium(IV) solutions can be standardised as follows:

The primary standard arsenic(III) oxide is dissolved in sodium hydroxide solution which converts it to arsenite ion:

$$As_2O_3 + 6\,OH^- \rightarrow 2\,AsO_3^{3-} + 3\,H_2O$$

Dilute sulfuric acid is then added to give arsenious acid:

$$AsO_3^{3-} + 3\,H^+ \rightarrow HsAsO_3$$

The arsenious acid is then titrated with cerium(IV) sulfate solution, using osmium tetraoxide as catalyst and ferroin as indicator:

$$H_3AsO_3 + 2\,Ce^{4+} + H_2O \rightarrow H_3AsO_4 + 2\,Ce^{3+} + 2\,H^+$$

A 0.2476 g sample of arsenic(III) oxide is treated as described above, and ultimately when the sample is titrated, it requires 46.34 mL of unknown cerium(IV) sulfate solution.

(a) Use the above equations to work out how many moles of cerium(IV) ion will react with the arsenious acid produced from 1 mole of arsenic(III) oxide.

(3 marks)

(b) Use this value to calculate the concentration of the $Ce(SO_4)_2$ solution.

(5 marks)

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END OF PART 3

PART 4 : EXTENDED ANSWERS

Answer ONE of the following extended answer questions. Where applicable use equations, diagrams and illustrative examples of the chemistry you are describing.

Marks are awarded principally for the relevant chemical content of your answer, but some marks can also be gained for clarity in arranging a reasonable amount of material in a coherent form. Your answer should be presented in about $1^1/_2$ — 2 pages, and should be written in the space beginning on page 31. This part carries 20 marks (10% of the total).

1. A chemist placed the following order with a chemical company:

   Please supply

   500 mL of octane
   500 mL of butanoic acid
   500 mL of 1-butanol
   500 mL of 2-methyl-2-butanol
   500 mL 0.10 mol L^{-1} sodium carbonate
   500 mL 0.10 mol L^{-1} oxalic acid.

   Unfortunately when the goods arrived the chemist found that the labels had fallen off and were inside the box with the unlabelled bottles.

   Devise a series of suitable chemical tests that would enable her to re-label the bottles correctly. You **MUST** provide equations and full descriptions of any reactions that take place. You must explain clearly how the tests would help her identify the chemicals.
   You may assume that the laboratory has a complete supply of common chemicals and test papers.

OR

2. Use your knowledge of the chemistry of the elements of the Periodic Table to discuss the way in which the following vary across the Table:

   * Physical properties of the elements.
   * Oxidising and reducing properties of the elements.
   * Properties of the oxides of the elements.

   When describing these variations you should make specific reference to at least four elements.

OR

3. Explain how the method used to extract a metal from its ore is related to the reactivity of the metal.

   Describe three different common methods of extracting metals from their ores. Illustrate your answer with an example of each method.

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