IONA PRESENTATION COLLEGE

Year 12 Chemistry

Semester One Examination, 2001

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	2	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

Answer **ALL** questions, using a pen, on the separate Multiple Choice Answer Sheet.

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.

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)].

PART 1

(60 marks = 30% of the total)
Answer **ALL** questions in Part 1 on the Separate Multiple Choice Answer Sheet provided.

1. Which one of the following, in the solid state, has a crystal structure which contains discrete molecules?

    (a)   Magnesium chloride
    (b)   Hydrogen chloride
    (c)   Iron (II) chloride
    (d)   Sodium chloride

2. The successive ionization energies (in kJ mol^{-1}) of an element X are 500, 1010, 5200, 7100, 9200. Which of the following ions is most likely to be formed when X reacts with bromine to form an ionic bromide?

    (a) $X2^-$
    (b) X^-
    (c) X^+
    (d) X^{2+}

3. A, B and Z are elements in the same period of the Periodic Table. The oxide of A dissolves in water to form a solution which changes blue litmus paper pink. B reacts with waster forming a solution which changes pink litmus to blue. The oxide of Z reacts both with acids and alkali. If the elements were arranged in order of increasing atomic number which would be the correct order?

    (a)   ABZ
    (b)   AZB
    (c)   BZA
    (d)   BAZ

4. In which one of the following pairs are both elements more electronegative than carbon?

    (a)   Ar and Ne
    (b)   B and N
    (c)   Ge and Si
    (d)   N and O

5. How many *d*-electrons are present in a krypton atom, $_{36}Kr$, in its ground state?

    (a)   0
    (b)   10
    (c)   18
    (d)   28

6. How many valence-shell electrons (bonding and non-bonding) are present altogether in a sulfite ion, SO_3^{2-}?

    (a)   2
    (b)   8
    (c)   24
    (d)   26

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7.   A saturated solution of sodium chloride is prepared, and then a small quantity of solid sodium chloride containing the artificial radioactive isotope ^{36}Cl is added. Which one of the following describes what takes place in the solution?

        (a)   The sodium ion concentration increases and the solution becomes radioactive.
        (b)   The sodium ion concentration decreases and the solution does **not** become radioactive.
        (c)   The sodium ion concentration remains unchanged and the solution becomes radioactive.
        (d)   The sodium ion concentration remains unchanged and the solution does **not** become radioactive.

8.   Which of the following **DOES NOT** have the electronic structure
        $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$?

        (a) S^{2-}
        (b) Al^{3+}
        (c) Ca^{2+}
        (d)   Ar

9.   What would be observed after an aqueous solution of iron (III) chloride was added to an aqueous solution of silver nitrate?

        (a)   A white precipitate settled out of a yellow solution.
        (b)   A brown precipitate in a colourless solution.
        (c)   A metallic precipitate in a pale green solution.
        (d)   No reaction visible with the naked eye.

10.   In which of the following substances (in the liquid state) should you least expect to find hydrogen bonding?

        (a) CH_3CH_2OH
        (b)   HF
        (c) NH_3
        (d) CH_4

11.   A pure substance is very soluble in water and also very soluble in cyclohexane. Which one of the following is it?

        (a)   Calcium nitrate
        (b)   Cyclohexene
        (c)   Ethanol, C_2H_5OH
        (d)   Trichloromethane $CHCl_3$

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12. Which of the following best explains why sodium chloride is almost insoluble in ethanol?

    (a) Sodium and chloride ions do not form strong enough interactions with ethanol to disrupt the sodium chloride crystal lattice and overcome the van der Waals forces in the ethanol.
    (b) Ethanol cannot interact with sodium ions or chloride ions, and hence sodium chloride will not dissolve.
    (c) Although both sodium chloride and ethanol are polar they are not similar enough for the "like dissolves like" rule to apply.
    (d) Sodium chloride and ethanol are both highly stable compounds and therefore do not react easily.

13. The first four successive ionization energies for element X are
    0.637 MJ mol^{-1} 1.24 MJ mol^{-1} 2.40 MJ mol^{-1} 7.10 MJ mol^{-1}
    Which of the following formulae is most likely for the chloride of element X?

    (a) $XC\ell$
    (b) $XC\ell 2$
    (c) $XC\ell 3$
    (d) $X_2 C\ell 3$

14. 0.0520 mol of sodium carbonate is dissolved in enough water to make 100.0 mL of solution. What is the concentration of the sodium carbonate in mol L^{-1}?

    (a) 0.00520 mol L^{-1}
    (b) 0.0260 mol L^{-1}
    (c) 0.0520 mol L^{-1}
    (d) 0.520 mol L^{-1}

15. Which statement is FALSE?

    (a) Within the crystal structure of sodium chloride, each sodium ion is surrounded by chloride ions.
    (b) Within the crystal structure of sodium chloride, each chloride ion is surrounded by sodium ions.
    (c) Within the crystal structure of sodium chloride, bonding between sodium ions and chloride ions is very strong.
    (d) Within the crystal structure of sodium chloride, there are molecules of NaCl, the building blocks of the crystal.

16. If some common salt, NaCl, is dissolved in water, which one of the following statements is TRUE?

    (a) The vapour pressure, melting point and boiling point of the solution are all higher than for pure water.
    (b) The vapour pressure of the solution is higher than water; the melting and boiling points are lower.
    (c) The vapour pressure and melting point of the solution are lower than water; the boiling point is higher.
   (d) The vapour pressure and boiling point of the solution are higher than water; the melting point is lower.

SEE NEXT PAGE

17.   Which one of the following four salt solutions is the most concentrated?

        (a)   10 g of salt dissolved in 10 mL of water.
        (b)   9 g of salt dissolved in 10 mL of water.
        (c)   6 g of salt dissolved in 5 mL of water.
        (d)   5 g of salt dissolved in 5 mL of water.

18.   When compounds are formed between the following pairs of elements, which ones are most likely to form predominantly covalent bonds?

                A   Potassium-chlorine.
                B   Oxygen-oxygen.
                C   Hydrogen-carbon.
                D   Caesium-fluorine.
                E   Chlorine-fluorine.

        (a)   B, C and E.
        (b)   B only.
        (c)   A and C.
        (d)   A and D.

19.   How many *d* electrons are present in a zinc atom, $^{64}_{30}$ Zn, in its ground state?

        (a)   8
        (b)   10
        (c)   18
        (d)   30

20.   Which one of the following has linear molecules at 25°C?

        (a) CS_2
        (b) $CaCl_2$
        (c) H_2S
        (d) SiO_2

21.   Water begins to boil when

        (a)   its vapour pressure is greater than the vapour pressure of water in the atmosphere.
        (b)   the average kinetic energy of the vapour particles is greater than the average kinetic energy of the water particles.
        (c)   the velocity of some molecules becomes high enough to escape from the water surface.
        (d)   Its vapour pressure is equal to the atmospheric pressure.

22.   Which two electrically neutral elements with the following electron populations would be most likely to form an ionic bond?

        (a)   11 and 12 electrons.
        (b)   11 and 17 electrons.
        (c)   12 and 14 electrons.
        (d)   17 and 16 electrons.

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23.   Five solutions were prepared by dissolving one mole of each of the salts listed below in one litre of water. Which solution would contain the greatest number of ions?

(a)   Calcium nitrate.
(b)   Sodium chloride.
(c)   Ammonium sulfate.
(d)   Aluminium nitrate.

24.   Which of the following **best** explains the polarity of carbon dioxide?

(a)   The CO_2 molecule is non-polar because, although the carbon/oxygen bond is polar, the molecule is linear.
(b)   The CO_2 molecule is non-polar because the valence electrons in the molecule are distributed evenly over the volume of the molecule.
(c)   The CO_2 molecule is polar because O is more electronegative than C.
(d)   The CO_2 molecule is polar because the molecule is bent (or V-shaped).

25.   Which of the following elements has the lowest melting point?

(a)   Lead.
(b)   Magnesium.
(c)   Silicon.
(d)   Sulfur.

26.   The diagram shows part of the DNA double helix in which the bases thymine (on the left) and adenine (on the right) are linked. What is the name given to the linking bonds, represented by the dotted lines?

(a)   Covalent bonds.
(b)   Hydrogen bonds.
(c)   Ionic bonds.
(d)   Metallic bonds.

SEE NEXT PAGE

27.   In the laboratory under the heading 'Effect of catalysts on reaction rate' you may have carried out
       the following experiment.
       •   Some hydrogen peroxide solution is added to sodium potassium tartrate solution: there is
               no evidence of reaction.
       •   The mixture is then heated to 65°C: there is still no evidence of reaction.
       •   A few drops of cobalt chloride solution are then added: the red colour of the cobalt
               changes to blue; the reaction mixture bubbles violently and the temperature rises rapidly;
               and after a few seconds the bubbles stop forming and the red colour returns.
       The overall reaction is

       $$C_4H_4O_6^{2-}(aq) \quad + \quad 5\,H_2O_2(aq) \quad \rightarrow \quad 3\,CO_2(g) \quad + \quad 7\,H_2O \quad + \quad CO_3^{2-}(aq)$$
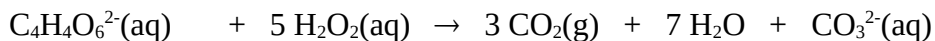
       Which one of the following reaction profiles is consistent with the experiment?

SEE NEXT PAGE

28. Which expression gives the equilibrium constant, K, for the following reaction in the gas phase?
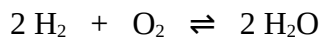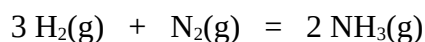
$$2 H_2 + O_2 \rightleftharpoons 2 H_2O$$

(a) $$K = \frac{[H_2O]^2}{[H_2]^2[O_2]}$$

(b) $$K = \frac{1}{[H_2]^2[O_2]}$$

(c) $$K = [H_2]^2[O_2]$$

(d) $$K = \frac{[2H_2O]}{[2H_2][O_2]}$$

29. Which one of the following statements about the following reversible reaction is TRUE?

$$3 H_2(g) + N_2(g) = 2 NH_3(g)$$

(Equilibrium constant = K. Heat of reaction = ΔH)
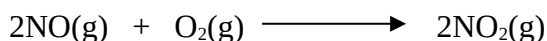
(a) $$K = \frac{[H_2]^3[N_2]}{[NH_3]^2}$$

(b) K is constant under all conditions.

(c) A catalyst increases the yield of ammonia by increasing ΔH.

(d) Ammonia is being formed when the gases are at equilibrium.

30. Consider the reaction:

$$2NO(g) + O_2(g) \longrightarrow 2NO_2(g)$$

Increasing the pressure of this system at constant temperature causes the rate of the reaction to increase. Which of the following statements best explains this observation?

(a) The volume of the reactants is greater than that of the products.

(b) The number of reactant molecules with energies greater than the activation energy for the reaction will increase.

(c) The total kinetic energy of the system will increase.

(d) The particles will collide more often.

END OF PART 1

PART 2

Answer **ALL** questions in Part 2 in the spaces provided below.
This part carries **70 marks** – 35% of the total.

1.   Give balanced equations for any reactions which occur in the following experiments.

In each case describe observations such as colour changes, precipitate formation (give the colour), or gas evolution (give the colour or describe as colourless) resulting from the chemical reaction. **Use ionic equations where appropriate**.

(a)   Potassium sulfate solution added to lead nitrate solution.

Equation _____

Observation _____

_____

(3 marks)

(b)   An aqueous solution of barium chloride is acidified with dilute sulfuric acid.

Equation _____

Observation _____

_____

(3 marks)

(c)   Copper nitrate solution added to sodium carbonate solution.

Equation _____

Observation _____

_____

(3 marks)

(d)   Ammonia solution is added to solid silver chloride.

Equation _____

Observation _____

_____

(3 marks)

SEE NEXT PAGE

2.   For each molecule or ion listed in the table below

        (i)   draw the structural formula,
                representing **all** valence shell electron pairs either as **:** or as **−**

                                        . .   —   . .
        (for example, water   H **:** O **:** H **or**   H − O — H)   **or**   H − O − H   and so on)
                                        . .   —   . .

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

| Molecule	Structural formula (showing all valence shell electrons)	Shape (sketch or name)
BF_3		
CO_3^{2-}		
chloromethane, CH_3Cl		

(6 marks)

3.   Write the equation for the industrial synthesis of ammonia.

        This reaction takes place exceedingly slowly at room temperature and pressure. List three ways in which chemists control reaction conditions to **speed up** the process.

i
ii
ii

(4 marks)

SEE NEXT PAGE

4.   Hydrogen sulfide, when bubbled through water, gives rise to a very low concentration of sulfide ion as a result of three equilibria:

$$H_2S(g) \rightleftharpoons H_2S(aq)$$
$$H_2S(aq) \rightleftharpoons HS^-(aq + H^+(aq)$$
$$HS^-(aq) \rightleftharpoons S^{2-}(aq) + H^+(aq)$$
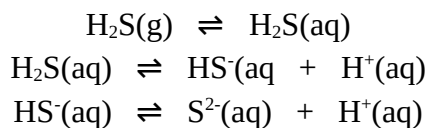
Five identical sets of apparatus are set up as illustrated, with hydrogen sulfide gas bubbled through water continuously.

Each apparatus is treated as described below: predict the effect on the sulfide ion concentration in the water.

Experiment	Effect on $[S^{2-}]$ Write 'increase', 'decrease' or 'no change'
One drop of concentrated hydrochloric acid is added to the water	
One sodium hydroxide pellet is dissolved in the water	
One drop of concentrated ammonia solution is added to the water	
A few crystals of ammonium chloride are dissolved in the water	
The gas escape tube is blocked so that the gas pressure increases	

(5 marks)

5.   When nickel nitrate solution is added to sodium phosphate solution, a green precipitate forms which settles below a colourless solution. Write the equation for the reaction that has occurred.

When cobalt sulfate solution is added to lanthanum chloride ($LaC\ell_3$) solution (which is colourless), a white precipitate forms which settles below a red solution. Write the equation for the reaction that has occurred.
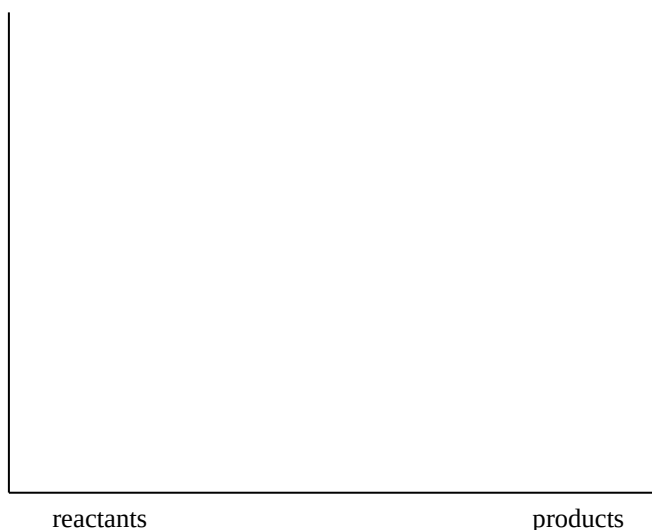

(4 marks)

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6.   For each of the following pairs of compounds, state which compound has the higher boiling point and indicate the type of van der Waal's force (dispersion, dipole-dipole, hydrogen-bonding) responsible for the difference between the boiling points. (One example has been done for you.)

Pair of compounds	Higher boiling compound	Intermolecular force responsible for difference
F_2 and Cl_2	Cl_2	dispersion force
C_2H_5OH and CH_3CH_3		
CH_2F_2 and CH_3F		
C_3H_8 and C_5H_{12}		

(6 marks)

7.   When white phosphorous, P_4, is left to stand in air, after a time it spontaneously ignites producing white fumes of tetraphosphorus decaoxide.

(a)   On the axes below draw a potential energy diagram for the reaction
(b)   Label the vertical co-ordinate.
(c)   Write the equation for the reaction in the box below.

reactants   products

Reaction co-ordinate

Equation:
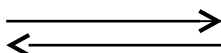
(4 marks)

SEE NEXT PAGE

8.   Ethene may be produced from ethane by heating it in the presence of a catalyst. The reaction can
      be represented by the equation:

      $C_2H_6(g) \rightleftharpoons C_2H_4(g) + H_2(g)$ $\Delta H = +120$ kJ mol^{-1}

      On the axes below

      (a)   draw a potential energy diagram for the uncatalysed reaction if the activation energy is
             180 kJ mol^{-1}.

      (b)   using a dotted line, draw a possible potential energy diagram for the same reaction in the
             presence of a catalyst.

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+300 —

+200 —

+100 —

Potential
Energy      0 —    ——————————
(kJ mol⁻¹)             (Ethane C₂H₆)

-100 —

-200 —

-300 —
          Reaction Co-ordinate  ———▶
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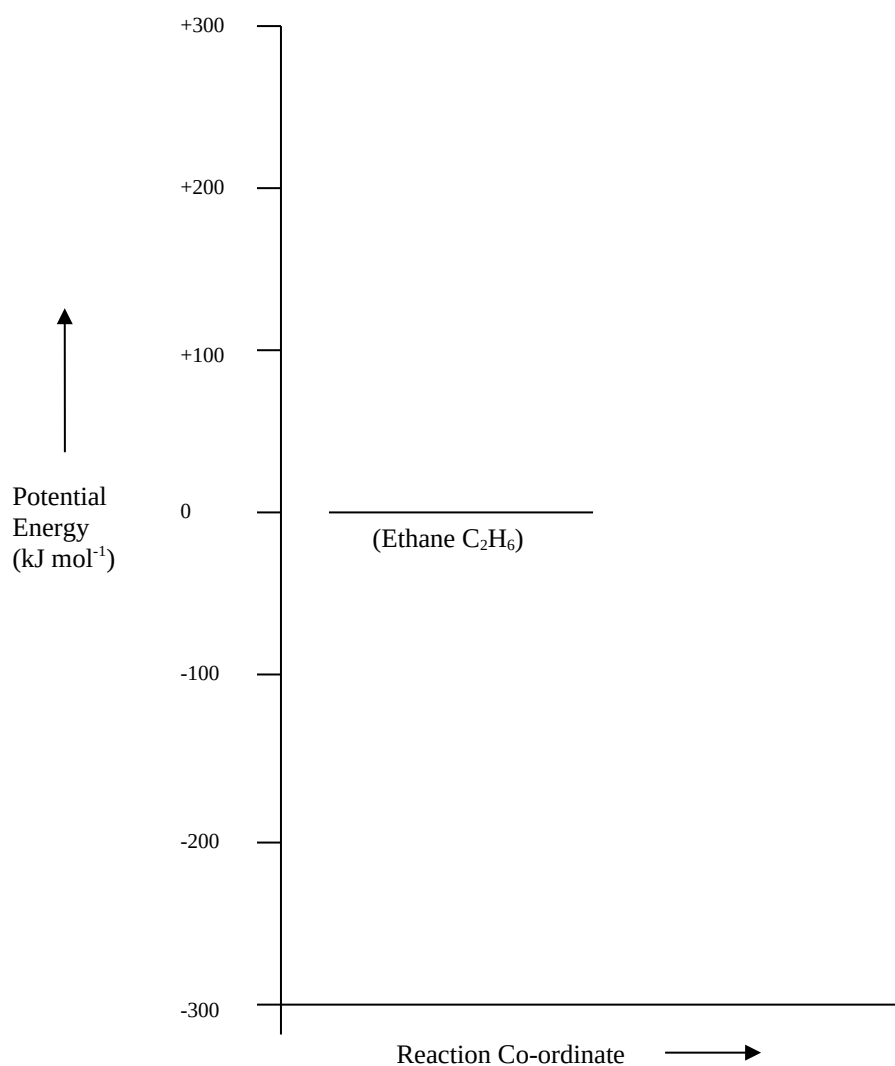
                                                                                          (4 marks)

                                         SEE NEXT PAGE

9. Examine the Periodic Table shown below:

																	(g)
																(f)	
											(d)		(e)				
				(c)													(h)
(a)																	
	(b)																

(i) What type of bonding would you expect to find in element (c) in the solid state?

Answer_____ **(1 mark)**

(ii) What type of bonding would you expect to find in the compound formed between elements (a) and (f)?

Answer_____ **(1 mark)**

(iii) What type of bonding would you expect to find in a compound of element (f) with hydrogen?

Answer_____ **(1 mark)**

(iv) How many atoms of (f) would combine with one atom of (d)?

**Answer**_____ **(1 mark)**

(v) Which of the elements labelled (a) to (h) would be likely to have a strongly basic hydroxide and form ions with a charge of +2?

Answer_____ **(1 mark)**

(vi) What would be the ground state electronic configuration of an atom of element (f)? (The notation you use should show principal energy levels and sub-shells.)

Answer_____ **(1 mark)**

SEE NEXT PAGE

10.   Calcium hydroxide is slightly soluble in water. The equilibrium established when solid $Ca(OH)_2$ is in contact with saturated solution is represented by

$$Ca(OH)_2(s) \rightleftharpoons Ca^{2+}(aq) + 2\, OH^-(aq)$$
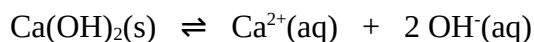
An equilibrium mixture of solid calcium hydroxide and its saturated solution is prepared. Four test tubes are set up, each containing some of the equilibrium mixture—a little white solid under a colourless solution. Each of the tubes is treated as described below. In each case state how the equilibrium will shift, and what will be observed.

What is done	How the equilibrium shifts. Write '→', '←', or 'no change'	What is observed. Give the complete observation
A little concentrated hydrochloric acid is added to the first tube		
A little concentrated (3 mol L^{-1}) calcium chloride solution is added to the second tube		
A little solid calcium hydroxide is added to the third tube and the mixture shaken		
A little solid sodium chloride is added to the fourth tube and the mixture shaken		

(8 marks)

11.   Write the equilibrium constant expression for each of the following:

Equation	$Fe(H_2O)_5NCS^{2+}(aq) + H_2O(\ell) \rightleftharpoons Fe(H_2O)_6^{3+}(aq) + NCS^-(aq)$
Equilibrium constant expression	

Equation	$2\, NOC\ell(g) \rightleftharpoons 2\, NO(g) + C\ell_2(g)$
Equilibrium constant expression	

(4 marks)

12.   The electron configuration of the lithium atom is $1s^2\, 2s^1$. Using the same notation, give the electron configuration of

(a)   a sulfur atom, S,_____

(b)   a potassium ion, K$^+$,_____

(c)   a hydride ion, H$^-$,_____

(3 marks)

SEE NEXT PAGE

13.   The boiling points of the hydrides of the Group V elements are shown in the graph below

Boiling point (K)

280 —

240 —

200 —

160 —

NH₃
X

X
PH₃

X
AsH₃

X
SbH₃

X
BiH₃

0   40   80   120   160   200   240

Molecular weight
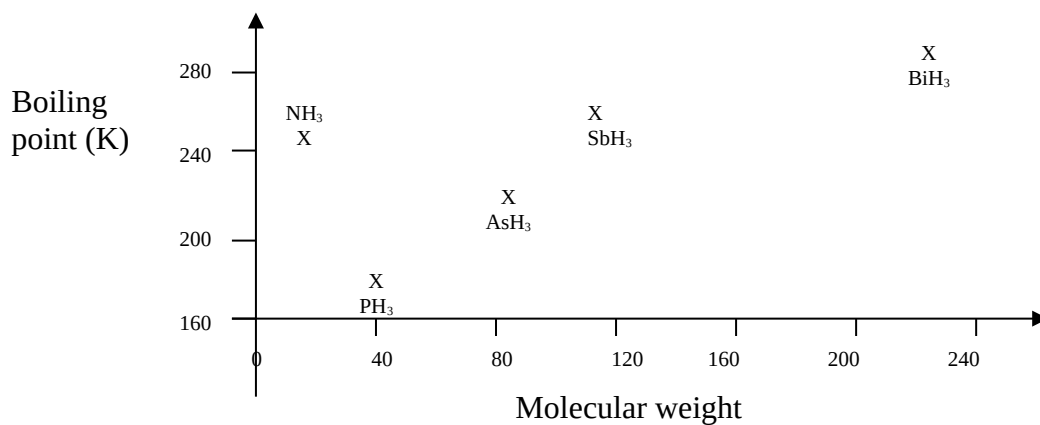
(a)   Account for the trend in boiling point from PH₃ to BiH₃.

(2 marks)

(b)   Account for the relatively high boiling point of NH₃.

(2 marks)

END OF PART 2

PART 3

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, clearly distinguish each section using (a), (b), and so on. Correct final numerical answers to three (3) significant figures where appropriate, and provide units where applicable. Information which may be necessary for solving the problems is located on the separate Chemistry Data Sheet. Show clear reasoning: if you don't, you will lose marks. This part carries 50 marks (25% of the total).

1.   A pure substance 'A' is a white solid, melting at 153°C, which is found by qualitative analysis to contain carbon and hydrogen. With no simple test for oxygen available, it can be assumed oxygen might be present.

When 0.8062 g of 'A' is burnt in a current of dry oxygen, 1.110 g of carbon dioxide and 0.303 g of water are produced.

Calculate the empirical formula of 'A'.

(7 marks)

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2. A pure substance 'A' is a white solid which sublimes at 76°C and melts under pressure at 158°C. 'A' Burns readily in air leaving no ash, and qualitative analysis shows that nitrogen, sulfur, and the halogens are absent. It may thus be concluded that 'A' contains the elements carbon and hydrogen, and possibly oxygen.

   (a) In an experiment, 0.5991 g of 'A' is burnt in a current of dry air, and 1.334 g of carbon dioxide and 0.233 g of water are produced. Calculate the empirical formula of 'A'.

   (6 marks)

   (b) At 100°C and 1.00 atm pressure, 0.331 g of 'A' evaporates to occupy a volume of 72 mL. Calculate the molecular weight of 'A'.

   (5 marks)

   (c) What is the molecular formula of 'A'?

   (1 mark)

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2.   Magnesium metal reacts with dilute hydrochloric acid to form hydrogen gas.

       (a)   Write the equation for this reaction.

                                                                                (2 marks)

       (b)   0.1046 g of magnesium is added to 50.00 mL of 0.1000 mol L^{-1} hydrochloric acid. Which
               reactant is the limiting reactant?

                                                                                (4 marks)

       (c)   State or calculate each of the following when the reaction has reached completion:

               (i)   the mass of magnesium remaining.
               (ii)   the number of moles of hydrogen ion remaining.
               (iii)   the volume of hydrogen gas produced, dried and measured at 25°C and 1.000 atm.
               (iv)   the concentration of magnesium ion in the 50.0 mL of solution.

                                                                                (6 marks)

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4. The owner of a fresh water swimming pool of volume 31500 L wishes to chlorinate it for the first time using calcium hypochlorite, $Ca(ClO)_2$.

(a) What mass of calcium hypochlorite should be added such that the final concentration of the hypochlorite ion is 15.0 parts per million?
(you may assume that 1 part per million = 1 mg L^{-1})

(b) The pool owner actually added more calcium hypochlorite than was necessary.

After some days **all** of the hypochlorite ion had been reduced to chloride according to the equation:

$$2e^- + 2H^+ + OCl^- \longrightarrow Cl^- + H_2O$$
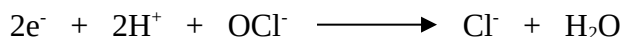
A sample of the pool water was analysed for chloride ion by adding excess silver nitrate and weighing the silver chloride which was precipitated. A 200.0 mL sample of pool water produced 0.0362 g of dry silver chloride. What mass of calcium hypochlorite did the pool owner actually put into the pool?

(7 marks)

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5. 2.00 L of propane (C_3H_8), 30.0 L of oxygen and 15.0 L of nitrogen, all at 1.00 atm and 25°C, were introduced into the cylinder illustrated. A spark was used to ignite the gas mixture.

    (a)   Write the equation for the reaction that has occurred.

(2 marks)

The water in the mixture is frozen out, and removed from the cylinder.

    (b)   The original conditions of temperature and pressure are then restored. Calculate the volume and composition (by volume) of the gas mixture.

(6 marks)

    (c)   Calculate the volume of water produced, at 1.00 atm and 25°C. (1.00 mL of water weights 1.00 g)

(4 marks)

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END OF PART 3

PART 4

(20 marks = 10% of paper)

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

Marks are awarded for the relevant chemical content of your answer, but you will lose marks if what you write is unclear or lacks coherence. Your answer should be presented in about $1^1/_2$ – 2 pages.

EITHER

1.   Read this information and answer both parts (a) and (b) in the spaces the below.

The graphite structure, as you would expect, is different from diamond. Carbon atoms are held tightly together in layers. Each carbon atom has three covalent bonds to other carbon atoms. Hexagons of carbon atoms are formed. Weak bonds hold every layer to the one above and the one below. The forces between layers are weak, so they can slide past each other. This explains why graphite is soft and flaky. The electrons between the layers are free to move, as in metals, allowing graphite to conduct electricity in the direction of the layers. The layers themselves are very strong. Graphite fibres with the layers arranged along the fibre are stronger than steel. They are used as reinforcement in metals. Graphite fibres have even been used to reinforce broken bones in animals.

(a)   Describe briefly the structure and bonding in each of the following solids:

Lead, Iodine, Diamond.

(10 marks)

SEE NEXT PAGE

1.   (b)   Use your descriptions and the information about graphite to answer these questions:

(10 marks)

(i)   Why are both graphite and iodine soft flaky solids?

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(ii)   Why does graphite have a melting point of 3720°C and yet iodine has a melting point of only 114°C?

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(iii)   Pencil "leads" are a mixture of graphite and clay. They get their name because graphite was confused with lead metal. What properties of graphite and lead are similar?

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(iv)   Why, in terms of their structures and bonding are lead and graphite similar in these ways?

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(v)   Diamond is one of the hardest substances known. Explain why it is so different to graphite in this respect.

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OR

2.   An industrial method for the manufacture of nitric acid is the Ostwald Process, and the reactions involved are described as follows:

Stage	Description	Equation	ΔH (kJ)
1	NH_3 and O_2 are heated together at $800°C$ in the presence of a platinum catalyst.	$4\,NH_3(g) \;+\; 5\,O_2(g) \;\rightarrow\; 4\,NO(g) \;+\; 6\,H_2O(g)$	-908
2	O_2 is added to the NO from Stage 1.	$2\,NO(g) \;+\; O_2(g) \;\rightarrow\; 2\,NO_2(g)$	-114
3	The NO_2 from Stage 2 is bubbled through water.	$2\,NO_2(g) \;+\; H_2O(\ell) \rightarrow HNO_2(aq) \;+\; H^+(aq) \;+\; NO_3^-(aq)$	-106
4	The HNO_2/HNO_3 mixture from Stage 3 is heated to produce concentrated nitric acid. (The NO is recycled into Stage 2.)	$3\,HNO_2(aq) \rightarrow H^+(aq) \;+\; NO_3^-(aq) \;+\; H_2O(\ell) \;+\; 2\,NO(g)$	+44

Each stage can be summarized by a reaction diagram showing initial state, transition state and final state. Sketch such a reaction diagram for each stage. Use your diagrams and your knowledge of rate and equilibrium principles to explain why the conditions have been chosen for each stage in the process.

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Space for diagrams question 2.

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