Chemistry 3A

Semester One Examination, 2010

Question/Answer Booklet

NAME: _____

TEACHER: _____

Marker use only

Part		Marks achieved	Marks available
1	Multiple choice	/50	50 (33%)
2	Short answer	/60	60 (40%)
3	Extended answers	/40	40 (27%)
	TOTAL		150 (100%)

%

Time allowed for this paper
Reading time before commencing work: Ten minutes
Working time for paper: Two and a half hours

Materials required/recommended for this paper
To be provided by the supervisor
This Question/Answer Booklet
Separate Multiple Choice Answer Sheet
Separate Chemistry Data Sheet

To be provided by the candidate
Standard Items: Pens, pencils, eraser or correction fluid and ruler
Special Items: A 2B, B or HB pencil for the separate Multiple Choice Answer Sheet and calculators satisfying the conditions set by the Curriculum Council for this subject.

Important note to candidates
No other items may be taken into the examination room. 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.

SEE NEXT PAGE

Structure of this paper

Part	Number of questions available	Number of questions to be attempted	Suggested working time (minutes)	Marks available
1 Multiple choice	25	ALL	50	50 (33%)
2 Short answer	9	ALL	60	60 (40%)
3 Extended answers	4	ALL	30	40 (27%)
			Total marks	150 (100%)

Instructions to candidates

Answer the questions according to the following instructions:
Part 1: Answer **all** questions, using a 2B, B or HB pencil 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 on the Multiple Choice Section do this.

Parts 2 and 3 Write your answers in the spaces provided in this Question/Answer Booklet. A blue or black ball point or ink pen should be used.

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.

The examiners recommend that you spend your reading time mainly reading the Instructions to Candidates and Parts 2 and 3.

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

Chemical Equations
For full marks, chemical equations should refer only to those specific species consumed in the reaction and the new species produced. These species may be **ions** [for example $Ag^+_{(aq)}$], **molecules** [for example $NH_{3(g)}$, $CH_3COOH_{(l)}$, $CH_3COOH_{(aq)}$] or **solids** [for example $BaSO_{4(s)}$, $Cu_{(s)}$, $Na_2CO_{3(s)}$].

PART 1   **(50 marks = 33% of paper)**

Question 1.

An old bottle of aqueous sodium chloride (molar mass = 58.5 g mol^{-1}) was labelled as 15000 ppm. Which of these would be the correct concentration of this solution in mol L^{-1}?

(Assume density of solution = 1.00 g mL^{-1})

(a)   2.57 mol L^{-1}

(b)   0.257 mol L^{-1}

(c)   25.7 mol L^{-1}

(d)   0.0257 molL^{-1}

Question 2.

Which of the following pairs of solutions would form a white precipitate when mixed?

(a)   sodium nitrate and cobalt chloride

(b)   ammonium carbonate and zinc chloride

(c)   copper(II) chloride, and potassium hydroxide

(d)   iron(II) sulfate and sodium nitrate

Question 3.

The first five ionisation energies of an element are as follows:

584 kJ mol^{-1} 1823 kJ mol^{-1} 2751 kJ mol^{-1} 11584 kJ mol^{-1} 14837 kJ mol^{-1}

The element is most likely to be:

(a)   Na

(b)   Mg

(c)   Al

(d)   Si

SEE NEXT PAGE

Question 4.

The electronegativities of four elements are given below: (they are not represented by their chemical symbols)

W = 2.0   X = 2.1   Y = 3.4   Z = 1.0

Which of the following pairs of atoms are **most likely** to form molecules that contain polar covalent bonds?

(a)   Z and Y

(b)   X and X

(c)   X and Y

(d)   W and X

Question 5.

The shape of the molecules formed by the combination of atoms with the electronic configurations:

2, 7 and 2, 5

will be:

(a)   linear

(b)   pyramidal

(c)   bent

(d)   trigonal planar

Question 6.

In which of the following pairs of substances would the **strongest** interactions occur between molecules of the solute and the solvent?

	Solute	Solvent
(a)	I_2	C_6H_{12}
(b)	C_8H_{18}	H_2O
(c)	C_2H_5OH	H_2O
(d)	C_8H_{18}	CCl_4

SEE NEXT PAGE

Question 7.

The melting points of group VII hydrides is given below

Formula	Melting point($^{\circ}$C)
HF	***
HCl	-114
HBr	-87
HI	-51

The **most likely** value for the melting point of HF is:

(a) $-140\ ^{\circ}$C

(b) $-90\ ^{\circ}$C

(c) $-170\ ^{\circ}$C

(d) $+170\ ^{\circ}$C

Question 8.

Hydrogen is manufactured from natural gas (methane) through the following **endothermic** reaction:

$$CH_{4(g)} + H_2O_{(g)} \rightleftharpoons 3H_{2(g)} + CO_{(g)}$$
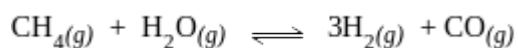
Which of the following statements about this process is **false**?

(a)   Increasing the temperature will increase the rate of the forward reaction

(b)   Increasing the pressure will mean that the equilibrium yield of hydrogen increases.

(c)   Removing carbon monoxide will encourage the formation of hydrogen.

(d)   Using a catalyst may speed up the forward reaction.

SEE NEXT PAGE

Question 9.

A mixture of $SO_{2(g)}$ and $O_{2(g)}$ at a fixed temperature reacts according to the equation:

$$2SO_{2(g)} + O_{2(g)} \rightleftharpoons 2SO_{3(g)}$$
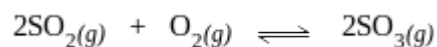
Which of the following gives the correct expression for the equilibrium constant for this reaction?

(a) $\dfrac{[SO^3]}{[SO_2][O_2]}$

(b) $\dfrac{[SO^3]^2}{[SO_2][O_2]}$

(c) $\dfrac{[SO^3]^{2-}}{[O_2][SO_2]^2}$

(d) $\dfrac{[SO^3]}{[SO_2][O_2]^2}$

Question 10.

The equation for the formation of ammonia gas during the Haber process is shown below:

$$N_{2(g)} + 3H_{2(g)} \xrightleftharpoons{\text{Fe catalyst}} 2NH_{3(g)} + \text{HEAT}$$
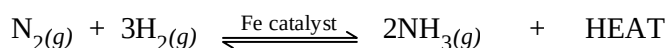
The reaction conditions are 450°C and 100 atmospheres pressure.
Which of the following statements is **true**?

(a)   The equilibrium amount of $NH_3(g)$ is increased as the temperature is further increased.

(b)   The equilibrium amount of $NH_3(g)$ is increased as the pressure is further increased.

(c)   The equilibrium amount of $NH_3(g)$ is increased as additional Fe is added.

(d)   The rate of the reaction is decreased as the temperature is further increased.

SEE NEXT PAGE

The following information refers to Questions 11 and 12.

An element **X** contains atoms that have a ground state configuration of 2,8,6.

Question 11.

The **ions** of element **X** would most likely have a charge of:

(a)   4+

(b)   2+

(c)   2-

(d)   6+

Question 12.

The bonds present in the compound H_2X are most likely to be:

(a)   Single covalent bonds.

(b)   Double covalent bonds.

(c)   Ionic bonds.

(d)   Hydrogen bonds.

Question 13.

Which of the following has the **highest** electronegativity?

(a)   Li

(b)   Be

(c)   N

(d)   O

SEE NEXT PAGE

Question 14.

Which of the following species will be **linear** in shape?

(a) NH_3

(b) H_2O

(c) C_2H_2

(d) SO_2

Question 15.

Which of the following correctly describes the dominant intermolecular forces occurring in the following substances?

	C_8H_{18}	NH_3	CCl_4
(a)	Dispersion Forces	Hydrogen Bonding	Dipole-Dipole
(b)	Hydrogen Bonding	Dipole-Dipole	Dispersion Forces
(c)	Hydrogen Bonding	Dipole-Dipole	Dipole-Dipole
(d)	Dispersion Forces	Hydrogen Bonding	Dispersion Forces

Question 16.

As you go **down** Group II from Be to Ra, which of the options below correctly describes the trends in the characteristics of the elements?

	Electronegativity	1st Ionisation Energy	Electrical Conductivity
(a)	Decreases	Decreases	Increases
(b)	Increases	Decreases	Decreases
(c)	Decreases	Increases	Increases
(d)	Increases	Increases	Decreases

SEE NEXT PAGE

Question 17.

A student had 100.0 mL of 1.00 mol L^{-1} hydrochloric acid and was asked to reduce the concentration to 0.200 mol L^{-1}. What volume of distilled water would she need to add to her solution?

(a)   400.0 mL

(b)   500.0 mL

(c)   300.0 mL

(d)   20.0 mL.

Question 18.

Which of the following formulae have been named correctly, based on the IUPAC nomenclature?

	Formula of substance	IUPAC name
(a)	$Fe(NO_3)_2$	Iron(III) nitrate
(b)	$CrPO_4$	Chromium(III) phosphate
(c)	$AlCl_3$	Aluminium(III) chloride
(d)	Na_2CO_3	Sodium(II) carbonate

Question 19.

Which of the following particles has 10 electrons, 12 neutrons and 11 protons?

(a) Na^+

(b) Ne^-

(c) Mg^{2+}

(d) Al^{3+}

Question 20.

Which of the following electron configurations of neutrally charged atoms is **not** from an element in Group II of the periodic table?

(a)   2

(b)   2, 2

(c)   2, 8, 2

(d)   2, 8, 8, 2

Question 21.

X_3Y_2 is the formula of a soluble salt. The dissociation of this salt in water produces which of the following?

(a) X^{3+} and Y^{2-}

(b) X^{2+} and Y^{3-}

(c) $X(OH)_2$ and H_3Y

(d) X_3Y_2 molecules

Question 22.

In moving left to right across a period of the periodic table, which of the following generally increases?

(a)   Atomic radius

(b)   Metallic character

(c)   Reactivity

(d)   First ionization energy

Question 23.

The following table shows the conductivities of substances L, M and N.

Substance	Electrical conductivity
L	Conducts electricity in solid and molten states
M	Conducts electricity in aqueous and molten states
N	Does not conduct electricity in any state

The substances are most likely to be which of the following?

	L	M	N
(a)	sulfur	potassium chloride	magnesium
(b)	potassium chloride	magnesium	sulfur
(c)	magnesium	potassium chloride	sulfur
(d)	magnesium	sulfur	potassium chloride

Question 24.

Which of the following statements are **not true**?

I NH_3 contains one pair of non-bonded electrons
II H_2S contains two pairs of shared electrons
III CO_2 contains two pairs of shared electrons
IV $CHCl_3$ contains no non-bonded electrons

(a) I and II.

(b) I and III.

(c) II, III and IV.

(d) III and IV.

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Question 25.

Chlorine and oxygen react to form a compound, oxygen dichloride. Which of the following is **correct**?

(a)   The compound has the formula OCl_2 and is soluble in polar organic solvent.

(b)   The compound is a strong electrolyte and has a low melting point.

(c)   The compound has the formula OCl_2 and is a strong electrolyte.

(d)   The compound has a high melting point and is very soluble in water.

END OF PART 1

PART 2   (60 marks)

Answer **ALL** questions in Part 2 in the spaces provided below.
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Question 26.

Give fully balanced equations for the reactions which occur (if at all) 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 (give the colour or describe as colourless) resulting from the chemical reaction.

a)   A dilute solution of hydrochloric acid is added to solid zinc oxide.

Equation _____

[2 marks]

Observation _____

_____

[2 marks]

b)   A solution of sodium carbonate is added to a solution of copper(II) nitrate.

Equation _____

[2 marks]

Observation _____

_____

[2 marks]

c)   A dilute solution of potassium hydrogen carbonate is added to a dilute solution of sulphuric acid.

Equation _____

[2 marks]

Observation _____

_____

[2 marks]

SEE NEXT PAGE

Question 27.

Yellow iron(III) ions and colourless thiocyanate ions establish equilibrium in aqueous solution as shown in the equation below:

$$Fe^{3+}(aq) + SCN^{-}(aq) \rightleftharpoons FeSCN^{2+}(aq)$$
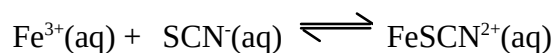
The iron(III) thiocyanate ($FeSCN^{2+}$) complex ion shown on the right hand side of the equation is dark red.

With reference to the above, certain changes are then imposed on the system at equilibrium.
Clearly state what you would observe after each change is made and apply Le Chatelier's Principle to account for each observation in the spaces allocated below.

    (a)   Some concentrated colourless sodium thiocyanate (NaSCN) solution is added.

Observation : ....
                                             [1 mark]
Explanation : ....
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                                             [2 marks]

    (b)   A small amount of concentrated potassium nitrate solution is added.

Observation : ....
                                             [1 mark]
Explanation : ....
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                                             [2 marks]

SEE NEXT PAGE

Question 28.

Using carefully drawn diagrams, thoroughly **explain** the difference in shape and polarity between BF_3 molecules and PF_3 molecules.

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[4 marks]

Question 29.

Explain the difference between the terms "electronegativity" and "ionisation energy".

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[3 marks]

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Question 30.

This question relates to the following reaction:

$$N_{2(g)} + O_{2(g)} \rightleftharpoons 2NO_{(g)} \qquad \Delta H = +180 \text{ kJ mol}^{-1}$$

Complete the table by predicting and explaining the effect on the position of equilibrium of the following imposed changes. (simply stating Le Chatelier's principle does not constitute an explanation)

Imposed change	Affect on equilibrium position to right, to left, or no change	Explanation
Increased Temperature		
Reduce the volume of the reaction vessel		
Remove some of the NO(g)		

[6 marks]

Question 31.

(a)   Write the equilibrium constant expression for the following reaction.

$$Co(H_2O)_6^{2+}{}_{(aq)} + 4Cl^-{}_{(aq)} \rightleftharpoons CoCl_4^{2-}{}_{(aq)} + 6H_2O_{(l)}$$
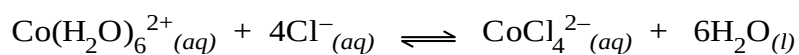
[2 marks]

(b)   Describe the effect on the position of equilibrium when

(i)   K is very small eg $K = 10^{-3}$

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[2 marks]

(ii)   K is small eg $K = 1$

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[2 marks]

Question 32.

Complete the table below by drawing correct Lewis (electron dot) diagrams, indicating whether the substance is polar or non polar and describe the type of bonding of the particle shown.

Formula	Lewis (electron dot) diagram	Polar or non polar	Type of force between molecules (if any)
H_2S			
	H : F̈ :		
NO_3^-			

[9 marks]

Question 33.

a)   Explain why sodium chloride dissolves in water whilst in kerosene or petrol (non polar substances) sodium chloride is relatively insoluble.

[3 marks]

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b)   Explain why iodine (I_2) is soluble in ethanol (CH_3CH_2OH), very soluble in carbon tetrachloride (CCl_4) but slightly soluble in water.   [3 marks]

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Question 34

Magnesium chloride is an environmentally friendly compound with many applications in the areas of medicine, food production and dust control. However, magnesium metal and chlorine gas have markedly different applications and properties.

With the aid of the data displayed below, explain the differences in properties of the three species.

Selected Physical Properties of Magnesium chloride, Magnesium metal and Chlorine gas.

	$MgCl_{2(s)}$	$Mg_{(s)}$	$Cl_{2(g)}$
Melting point	714 ºC	650 ºC	-101 ºC
Boiling point	1412 ºC	1107 ºC	-35 ºC
Electrical conductivity in solid state	Non-conductor	Conductor	Non-conductor

a)   Explain the observed differences in melting and boiling points of the three species and thus account for their conductivities.   (4 marks)

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SEE NEXT PAGE

b) $MgCl_{2(s)}$ is brittle compared to Mg(s) metal which is malleable.
Account for the brittle nature of $MgCl_{2(s)}$ and malleability of $Mg_{(s)}$ (the use of
diagrams may assist, however, is not essential).

(4 marks)

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END OF PART 2

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PART 3   (40 marks)

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 working, correct
equations and clear setting out, even if you cannot complete the problem. Note that if
an incomplete answer is given only partial marks will be awarded.
When questions are divided into sections, clearly distinguish each section using (a),
(b), and so on. Express your 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.

Question 35.

In an laboratory experiment solutions were added together without reacting.
150.0 mL of 0.100 mol L^{-1} magnesium nitrate, 100.0 mL of 0.0500 mol L^{-1} potassium
nitrate and 100 mL of 0.0500 mol L^{-1} iron (III) nitrate were added with water to make
5.00 L of solution.

[Density of solution 1.00 kg L^{-1}]

(a)   Find the final concentration of ferric (Fe^{3+}) ions in mol L^{-1}.
                                                    [2 marks]

(b)   Find the final concentration of nitrate (NO$_3^-$) ions in parts per million
        (ppm)   [4 marks]

(c)   Find the concentration of magnesium (Mg^{2+}) ions in grams per litre
        (g L^{-1}).   [3 marks]

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Question 36.

Chromium metal occurs mainly as the green mineral chromite, $Fe_2O_3.Cr_2O_3$. Chromium is extracted from chromite by heating the mineral in air with sodium carbonate to form sodium chromate according to the following balanced equation:

$$2Fe_2O_3.Cr_2O_3 + 4Na_2CO_3 + 3O_2(g) \rightarrow 2Fe_2O_3 + 4Na_2CrO_4(s) + 4CO_2(g)$$
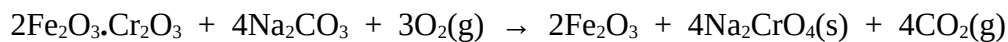
(a)   Calculate the mass of sodium carbonate needed to react with 1.00 tonne of chromite. [Hint: 1 tonne $=$ 10^3 kg or 10^6 g.]   [5 marks]

(b)   What volume of oxygen gas measured at 30.0°C and 98.0 kPa pressure is required for the reaction in (a) above?   [5 marks]

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Question 37.

In a laboratory experiment to prepare highly insoluble mercury(I) bromide, a student added 150.0 mL of 0.0502 mol L^{-1} mercury(I) nitrate solution to 250.0 mL of 0.0203 mol L^{-1} potassium bromide solution.

Note: mercury(I) = Hg_2^{2+}

(a)   Write the correct, balanced **reversible** equation for this reaction.
                                                                        [2 marks]

(b)   Show which reactant is the limiting reagent in this experiment.
                                                                        [4 marks]

(c)   Determine the theoretical mass of mercury(I) bromide the student would obtain.   [4 marks]

(d)   Why is the amount of mercury(I) bromide a "theoretical" mass?
                                                                        [1 mark]

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Read the information below to complete Question 38 on page 29.

The **Contact Process** is a process involving the catalytic oxidation of sulfur dioxide, SO_2, to sulfur trioxide, SO_3. The sulfur trioxide, SO_3, is added to water to produce sulfuric acid, H_2SO_4.

Step 1
Liquid sulfur, $S(l)$, is sprayed into a combustion chmaber containing dry air to form sulfur dioxide gas, SO_2 at 1000ºC.

$$S(l) + O_2(g) \leftrightarrow SO_2(g) \qquad \Delta H = -297 \text{ kJ mol}^{-1}$$

Step 2
The mixture of sulfur dioxide and air is heated to 450ºC and subjected to a pressure of 101.3 - 202.6 kPa (1 – 2 atmospheres) in the presence of vanadium(V) oxide to produce sulfur trioxide, $SO_3(g)$, with a yield of 98%.

$$2SO_2(g) + O_2(g) \leftrightarrow 2SO_3(g) \qquad \Delta H = -196 \text{ kJ mol}^{-1}$$

Any unreacted gases from the above reaction are recycled back into the above reaction.

Step 3
Sulfur trioxide, $SO_3(g)$ is dissolved in 98% (18M) sulfuric acid, H_2SO_4, to produce disulfuric acid or pyrosulfuric acid, also known as fuming sulfuric acid or oleum, $H_2S_2O_7$.

$$SO_3(g) + H_2SO_4 (l) \leftrightarrow H_2S_2O_7 (l) \qquad \Delta H = \text{-ve}$$
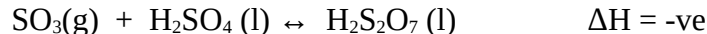
The above reaction is preferred because when water is added **directly** to sulfur trioxide to produce sulfuric acid according to the reaction

$$SO_3(g) + H_2O(l) \leftrightarrow H_2SO_4(l) \qquad \Delta H = -170 \text{ kJ mol}^{-1}$$
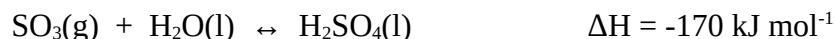
the reaction is slow and tends to form a mist in which the particles refuse to coalesce (come together) into a liquid.

Step 4
Water is added to the disulfuric acid, $H_2S_2O_7$, to produce sulfuric acid, H_2SO_4 at yields greater than 90%.

$$H_2S_2O_7(l) + H_2O(l) \leftrightarrow 2H_2SO_4(l) \qquad \Delta H = \text{-ve}$$

Steps 3 and 4 are performed at the lowest temperature possible (70 - 90ºC).

SEE NEXT PAGE

It is suggested that you write between 1½ and 2 pages to answer the following question.

Question 38.

The steps in the manufacture of sulfuric acid are described on page 28. Using this information
         a)   Give evidence to indicate whether equilibrium was present during specific reactions,
         b)   use Le Chatelier's Principle, and
         c)   Collision Theory to **explain** why certain conditions were used to **maximise** the yield of product in each reaction.

[10 marks]

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