Semester One Examination 2009

Question/Answer Booklet

YEAR 12 CHEMISTRY

Name: _____

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

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: 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.

Structure of this paper

Part	Number of questions available	Number of questions to be attempted	Suggested working time	Marks available
1. Multiple choice	20	All	35min	40 (25%)
2. Short answers	11	All	50min	60 (37.5%)
3. Calculations	6	All	45min	50 (31%)
4. Extended answers	1	All	20min	10 (6.5%)
			Total marks	160 (100%)

Instructions to candidates

1. 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 ball point 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.

   Parts 2 and 3 Write your answers in the spaces provided in this Question/Answer Booklet. A blue or black ball point pen or ink pen should be used. **Part 4** is to be answered on lined paper provided.

   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.

2. **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, molecules or solids.

Teacher use only:

	Mark	Out of
Part One		
Part Two		
Part Three		
Part Four		
Total		

PART 1 **(40 marks)**

Answer ALL questions on the separate multiple choice answer sheet provided. Each question in this part is worth 2 marks.

---

1. Which one of the following atoms in its ground state has the greatest number of valence electrons?

a) Al
b) P
c) S
d) Si

2. Two atoms, X and Y, have valence shell electron configurations of s^2p^4 and s^2. Which of the following would be the expected nature of a compound formed between X and Y?

a) covalent network
b) covalent molecular
c) ionic
d) molecular gas

3. Which one of the following chemicals is most suitable for use as a primary standard in an acid-base titration?

a) concentrated NH_3 solution
b) anhydrous Na_2CO_3
c) NaOH
d) hydrated Na_2CO_3

4. Consider the three weak acids, tellurous acid, H_2TeO_3, hydrazoic acid, HN_3, and nitrous acid, HNO_2. The conjugate bases of these acids would be

a) TeO_3^{2-}, NH_4^+ and HNO_2^+
b) $HTeO_3^-$, N_3^- and NO_2^-
c) $HTeO_3^-$, HN_2^- and NO_2^-
d) TeO_3^{2-}, NH_2^- and NO_3^-

5. Which one of the following equilibria in aqueous solution would not be affected by diluting the solution with water?

a) $[Co(H_2O)_6]^{2+}(aq) + 4Cl^-(aq) \leftrightarrow [CoCl_4]^{2-}(aq) + 6H_2O(l)$
b) $Cr_2O_7^{2-}(aq) + 2OH^-(aq) \leftrightarrow 2CrO_4^{2-}(aq) + H_2O(l)$
c) $Br_2(aq) + 2OH^-(aq) \leftrightarrow OBr^-(aq) + Br^-(aq) + H_2O(l)$
d) $HPO_4^{2-}(aq) + SO_4^{2-}(aq) \leftrightarrow PO_4^{3-}(aq) + HSO_4^-(aq)$

Refer to the following table listing some properties of four different substances for questions 6 and 7.

Substance	**m.p**	**b.p**	**Other properties**
A	2700ºC	Sublimes	Dull, hard, non-conductor of electricity
B	-68 ºC	57ºC	Oily liquid, non-conductor of electricity
C	-114ºC	-85ºC	Soluble in H_2O, solution conducts
D	2800ºC	3600ºC	Molten state conducts electricity

6. The substance which is most likely to be an ionic compound is

   a) A
   b) B
   c) C
   d) D

7. The substance which is most likely to be HCl is

   a) A
   b) B
   c) C
   d) D

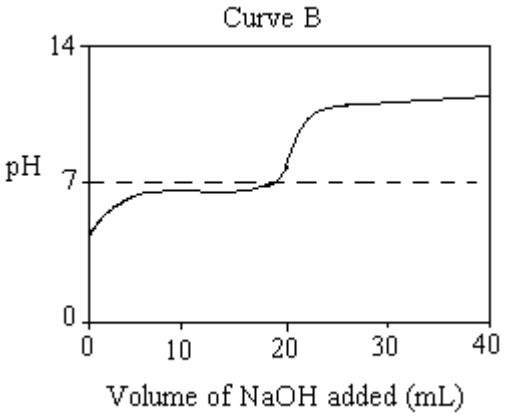
8. The first ionisation energy of phosphorus is greater than that of aluminium. The **best** explanation of this is

   a) the nucleus of a phosphorus atom has more protons than the nucleus of an aluminium atom and hence the valence electrons of phosphorus are more strongly held to the nucleus than those of aluminium.
   b) ionisation energy increases across a period in the Periodic Table and phosphorus is further across Period 3 than aluminium.
   c) the number of valence electrons in phosphorus is closer to a stable full shell than in aluminium and hence it is more difficult to lose an electron from phosphorus than aluminium.
   d) metals have higher ionisation energies than non metals and phosphorus is a non metal.

9. Which list consists of elements that have the most similar chemical properties?

   a) Mg, Al and Si
   b) K, Al and Ni
   c) Mg, Ca and Ba
   d) K, Ca and Ga

10. A titration was conducted by adding NaOH from a Teflon-coated burette to an acid in a conical flask. The pH in the flask was recorded during the titration and Curve B was produced.



The table shows appropriate indicators used to identify the equivalence point in titrations.

Indicator	*Acidic colour*	*Range of colour change*	*Basic colour*
Methyl orange	Red	3.1 – 4.4	Yellow
Methyl red	Red	4.4 – 6.2	Yellow
Bromothymol blue	Yellow	6.0 – 7.6	Blue
Cresolphthalein	Colourless	8.1 – 9.7	Red
Alizarin yellow	Yellow	10.1 – 12.0	Red

What is the appropriate indicator for Curve B using the table?

a) Methyl orange
b) Methyl red
c) Cresolphthalein
d) Alizarin yellow

11. Deuterium (symbol D) is an isotope of hydrogen. Water made from deuterium has the formula D_2O and has similar properties to normal water. D_2O ionises according to the equilibrium

$D_2O \leftrightarrow D^+ + OD^-$
$K = [D^+]\,[OD^-] = 1.82 \times 10^{-16}$ at 25ºC

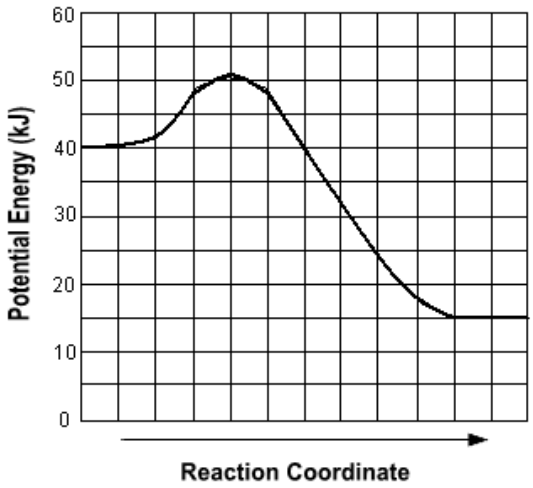
In a neutral solution of pure D_2O at 25ºC the concentration of D^+, in mole per litre, is

a) 1.00×10^{-7}
b) 1.35×10^{-8}
c) 0.91×10^{-16}
d) 1.82×10^{-16}

12. A student adds solid KCl to water in a flask. The flask is sealed with a stopper and thoroughly shaken until no more solid KCl dissolves. Some solid KCl is still visible in the flask. The solution in the flask is

    a) saturated and is at equilibrium with the solid KCl.
    b) saturated and is not at equilibrium with the solid KCl.
    c) unsaturated and is at equilibrium with the solid KCl.
    d) unsaturated and is not at equilibrium with the solid KC.l

13. Given the potential energy diagram for a chemical reaction:



    Which statement correctly describes the energy changes that occur in the forward reaction?

    a) The activation energy is 10 kJ and the reaction is endothermic.
    b) The activation energy is 10 kJ and the reaction is exothermic.
    c) The activation energy is 50 kJ and the reaction is endothermic.
    d) The activation energy is 50 kJ and the reaction is exothermic.

14. Which one of the following pairs of reactants will give a neutral solution when one mole of the first is mixed with one mole of the second?

    a) $HCl(aq) + Pb(NO_3)_2(aq)$
    b) $H_2SO_4(aq) + NaOH(aq)$
    c) $H_2SO_4(aq) + K_2O(s)$
    d) $CH_3COOH(aq) + NaOH(aq)$

15. Which symbol represents a particle that has the same total number of electrons as S^{2-}?

    a) O^{2-}
    b) Se^{2-}
    c) Si
    d) Ar

16. Which one of the following reactions has the largest initial rate of reaction? 100 g of powdered calcium carbonate is mixed with

a) 10.0 mL of 1.00 mol L^{-1} hydrochloric acid.
b) 80.0 mL of 1.00 mol L^{-1} hydrochloric acid.
c) 40.0 mL of 2.00 mol L^{-1} hydrochloric acid.
d) 5.0 mL of 4.00 mol L^{-1} hydrochloric acid.

17. Which one of the following substances, when dissolved in water, gives a solution with the lowest pH?

a) Li_2O
b) Na_2O_2
c) H_2SO_4
d) HI

18. Given the reaction system in a closed container at equilibrium and at a temperature of 298 K:

$$N_2O_4(g) \leftrightarrow 2NO_2(g)$$

The measurable quantities of the gases at equilibrium must be

a) decreasing.
b) equal.
c) increasing.
d) constant.

19. Which statement best describes the equivalence point in a titration between a strong acid and a strong base?

a) The point at which the first sign of a colour change occurs.
b) The point at which equal moles of acid and base have been added together.
c) The point at which equal moles of H^+ ions and OH^- ions have been added together.
d) The point at which the rate of the forward reaction equals the rate of the reverse reaction.

20. When iodine is dissolved in a solution of potassium iodide, an equilibrium is set up:

$$I^-(aq) + I_2(aq) \leftrightarrow I_3^-(aq)$$

Sodium thiosulfate ($Na_2S_2O_3$) reacts with iodine:

$$2S_2O_3^{2-}(aq) + I_2(aq) \rightarrow S_4O_6^{2-}(aq) + 2I^-(aq)$$

Which of the following changes would result when a solution of sodium thiosulfate is run from a burette into a solution of iodine in aqueous potassium iodide?

a) The concentration of I_3^- would decrease.
b) The concentration of I^- would increase.
c) The concentration of I_2 would increase.
d) The concentration of I^- and I_2 would remain constant.

PART 2 **(60 marks)**

Answer ALL questions in Part 2 in the spaces provided below.

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1. Write equations for any reactions that occur in the following procedures. If no reaction occurs write "no reaction".
   In each case describe **in full** what you would observe, including any
   - Colours
   - Odours
   - Precipitates (give the colour)
   - Gases evolved (give the colour or describe as colourless)

   If no change is observed, you should state this.

a) Solid sodium carbonate is added to a dilute solution of acetic (ethanoic) acid.

Equation _____

Observation _____

_____

(3 marks)

b) An excess of hot sodium hydroxide solution is added to a piece of zinc.

Equation _____

Observation _____

_____

(3 marks)

c) Solutions of cobalt chloride and sodium carbonate are mixed.

Equation _____

Observation _____

_____

(3 marks)

d) Dilute sulfuric acid is added to some copper.

Equation _____

Observation _____

_____

(3 marks)

2. Draw electron dot diagrams to represent the following substances.

OCl^-	BF_3
CS_2	NH_4NO_2

(4 marks)

3. Write down the electron configuration (using s, p, d notation) for the following species

a) nitride ion _____

b) potassium atom _____

(2 marks)

4. A crystal of iodine, heated gently in a test-tube, gave off a purple vapour. A crystal of sodium iodide, heated to the same temperature remained unchanged.

a) Explain the above observations in terms of structure and bonding.

_____

_____

_____

_____

_____

(3 marks)

b) Give the formula for the species responsible for the purple colour.

_____ (1 mark)

5. Pure water undergoes self-ionisation according to the following equilibrium:

$$2H_2O(l) \leftrightarrow H_3O^+(aq) + OH^-(aq)$$

The equilibrium constant for the ionisation of water (K_w) is 1.0×10^{-14} at 25ºC

The equilibrium constant expression for this reaction is

$$K = [H_3O^+][OH^-]$$

As the temperature is decreased the value of K_w decreases.

Is pure water acidic, basic or neutral at 10ºC? Explain your answer.

_____

_____

_____

(2 marks)

6. Consider the 0.1 mol L^{-1} solutions of:

Sodium hydroxide
Ammonium chloride
Sulfuric acid
Ethanoic(acetic) acid

a) Which solution would have the lowest electrical conductivity? Explain your answer.

_____

_____

_____

(3 marks)

b) Which solution would have the highest pH? Explain your answer.

_____

_____

_____

(2 marks)

c) Which solution would have the highest total concentration of ions?

_____

(1 mark)

7. Consider the following chemical substances.

PCl_3, SiO_2, $SiBr_4$, F_2, CS_2, BeH_2, NH_4I, HCOOH

List all the non-polar molecules	
List the molecules which would have hydrogen bonds between them	
List the pyramid-shaped molecules	

(6 marks)

8. Write equilibrium constants for the following chemical equilibria:

a) $TiO_2(s) + 2\ Cl_2(g) + 2\ C(s) \leftrightarrow TiCl_4(g) + 2\ CO(g)$

b) $[Fe(H_2O)_6]^{3+}(aq) + 6\ SCN^-(aq) \leftrightarrow [Fe(CN)_6]^{3-}(aq) + 6H_2O(l)$

a)	b)

(2 marks)

9. Calcium carbonate decomposes when heated

$$\text{Energy} + CaCO_{3(s)} \leftrightarrow CaO_{(s)} + CO_{2(g)}$$

If the mixture is present in a closed container equilibrium will be established.

Predict the effect of the following changes on the concentration of carbon dioxide at equilibrium and explain your predictions.

Change Imposed	Effect on conc of $CO_{2(g)}$	Explanation
The pressure inside the container is increased by reducing the volume of the container		
Helium gas is added		
A small quantity of $CaCO_{3(s)}$ is added		

(9 marks)

10. Describe briefly a chemical test and observations by which you could distinguish between the following pairs of chemical substances. Equations are not necessary.

Substances	Test	Observations
$Ba(NO_3)_{2(aq)}$ and $Pb(NO_3)_{2(aq)}$		
Silver chloride solid and Silver carbonate solid		

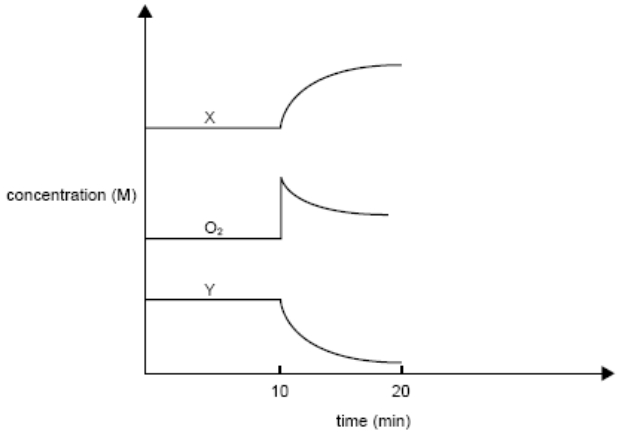
(4 marks)

11. Part of the Contact process for the manufacture of sulfuric acid involves the conversion of sulfur dioxide to sulfur trioxide as shown by the following equation

$$2SO_2(g) + O_2(g) \leftrightarrow 2SO_3(g) \quad \Delta H = -192 kJmol^{-1}$$

In a study of this process, a container was filled with an equilibrium mixture of sulfur dioxide, sulfur trioxide and oxygen in the presence of a catalyst. The container was initially at 450°C and was very well insulated.

An experiment was conducted on the container and the concentrations during the experiment are shown on the graph below:



a) What change was imposed on the system at the 10 minute point? (1 mark)

_____

b) Which components of the equilibrium mixture are represented by the lines labelled X and Y?

X _____ Y _____ (2 marks)

c) Give explanations for the changes in concentration that occur in X, Y and O_2 between 10 and 20 minutes

_____

_____

_____

_____

_____

_____

(3 marks)

d) Would the temperature of the mixture increase, decrease or remain the same between 10 and 20 minutes? Explain your answer

_____

_____

_____

_____

(3 marks)

END OF PART TWO

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PART 3 **(50 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 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. Express your final numerical answers to three (3) significant figures where appropriate. Information which may be necessary for solving the problems is located on the separate Chemical Data Sheet. Show clear reasoning: if you don't, you will lose marks.

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1. A sample of anhydrous barium chloride was dissolved in water to make 50.0 mL of solution. This solution was then mixed with 50.0 mL of 0.145 mol L^{-1} sodium phosphate solution. A white precipitate formed.

    a) Write an equation for the precipitation reaction (2 marks)

    b) What is the mass of precipitate found? (3 marks)

c) Calculate the concentration in mol L^{-1} of the sodium ions in the final solution. (3 marks)

2. If 50mL of water is added to 25mL of 2M H_2SO_4 what will be the pH of the resulting solution? (4 marks)

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3. Silicon carbide, SiC(s), is a very hard substance used in drill bits. It can be produced by the reaction between silicon dioxide and carbon to produce silicon carbide and carbon monoxide.

a) Write a balanced equation for the reaction. (1 mark)

b) If 125.6 kg of silicon dioxide is reacted with 63.5 kg of carbon. Determine the limiting reagent. (3 marks)

c) What mass of silicon carbide is produced when the quantities specified in part b are used? (2 marks)

d) What is the mass of excess reactant remaining at the end of the reaction?

(2 marks)

4. Zinc sulfate can be used as a dietary supplement in cases of suspected zinc deficiency. The compound crystallises as a hydrated salt.

a) In a simple experiment to determine the extent of hydration. 3.715 g of the crystals were carefully heated until no further loss in mass occurred. The anhydrous salt had a mass of 2.086 g.

i) How many moles of zinc sulfate are there in 2.086 g of anhydrous zinc sulfate? (1 mark)

ii) How many moles of water were lost? (2 marks)

iii) What is the value of X in the formula $ZnSO_4.XH_2O$?
(1 mark)

b) The daily recommended intake of zinc is 15.0 mg.

i) What mass of zinc sulfate crystals (hydrated) would need to be taken to obtain this intake? (3 marks)

ii) If this is taken via a 5.00 mL dose of aqueous zinc sulfate, what concentration of solution (in mol L^{-1}) needs to be prepared? (2 marks)

5. A tank contained industrial waste in the form of dilute hydrochloric acid. The first step in deciding how to treat this waste was to determine the concentration of the acid in the tank.

a) The concentration of the acid was determined by titration of 25.00 mL samples against 0.121 mol L^{-1} sodium hydroxide solution. The results are shown in the table below.

	Rough	1	2	3	4
Final Volume (mL)	42.6	38.10	32.55	45.10	38.75
Initial Volume (mL)	10.0	5.65	2.05	12.70	6.35
Titre (mL)	32.6				

i) Calculate the concentration in mol L^{-1} of the hydrochloric acid.

(1 mark)

ii) Calculate the total moles of HCl in the tank.

(4 marks)

The tank contained 4.00 x 10^3L of waste hydrochloric acid. It was decided to neutralise the acid in the tank using slaked lime, $Ca(OH)_2$.

b) The slaked lime was manufactured by roasting limestone and then adding water.

$$CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$$

$$CaO(s) + H_2O(l) \rightarrow Ca(OH)_2(s)$$

i) Write an equation for the reaction between solid slaked lime and hydrochloric acid.

(2 marks)

ii) If the limestone is only 92.3% pure what mass of limestone is required to produce enough slaked lime to neutralise the acid in the tank.

(5 marks)

6. Serotonin is a compound that transmits nerve impulses between neurons in the body. It contains carbon, hydrogen, nitrogen and oxygen.

   A 2.45g sample of serotonin was analysed and found to contain 68.15% carbon and 6.87% hydrogen.

   A second sample of 1.112g was analysed for its nitrogen content and found to contain 0.177g of nitrogen.

   a) Determine the empirical formula of serotonin. (5 marks)

b) On vaporisation 3.33g of serotonin was found to occupy 0.633L at 106.3kPa and 155^{o}C. Determine the molecular formula of the compound. (4 marks)

PART 4 **(10 marks)**

Answer the following extended answer question. 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, and also for coherence and clarity of expression. Your answer should be presented in about 1½ - 2 pages. Please answer this question on the lined paper provided.

The following table contains information about the melting points and conductivities of some substances.

Compound	**Melting point (°C)**	**Electrical Conductivity in aqueous solution**	**Electrical Conductivity in the liquid state**
Methylbutane $CH_3CH_2(CH_3)CH_2CH_3$	-160	n/a	very low
silicon	1410	n/a	very low
ethanoic acid (CH_3COOH)	17	moderate	low
water	0	low	low
sulfur (S_8)	113	n/a	very low

Discuss the forces between the particles involved in solid samples of the substances, and so account for their melting points and conductivities.

END OF PAPER

ANSWERS

Multiple choice

1	c	11	b
2	c	12	a
3	b	13	b
4	b	14	c
5	d	15	d
6	d	16	d
7	c	17	c
8	a	18	d
9	c	19	c
10	c	20	b

Part Two

1. a) solid sodium carbonate is added to a dilute solution of acetic (ethanoic) acid

Equation $Na_2CO_{3(s)} + CH_3COOH_{(aq)} \rightarrow CO_{2(g)} + H_2O + 2Na^+_{(aq)} + 2CH_3COO^-_{(aq)}$

Observation a white solid is added to a colourless solution and a colourless odourless gas is formed in a colourless solution

(3 marks)

b) an excess of hot sodium hydroxide solution is added to a piece of zinc

Equation $Zn(s) + 2OH^-(aq) + 2H_2O(l) \rightarrow H_2(g) + Zn(OH)_4]^{2-}(aq)$ (2mk)

Observation a silver/grey solid is added to a colourless solution and a colourless, odourless gas is formed in a colourless solution (1mk)

c) solutions of cobalt chloride and sodium carbonate are mixed

Equation $Co^{2+}(aq) + CO_3^{2-}(aq) \rightarrow CoCO_3(s)$ (2mk)

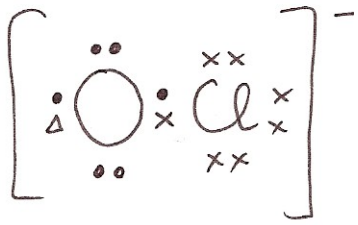
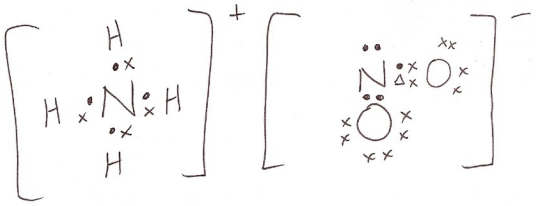
Observation a pale pink solution is added to a colourless solution and a pale pink solid in formed in a colourless solution (1mk)

d) dilute sulfuric acid is added to some copper

Equation no reaction (2mk)

Observation no visible change (1mk)

2. Draw electron dot diagrams to represent the following substances.

OCl^- 	BF_3 
CS_2 	NH_4NO_2 

(4 marks)

3. Write down electron configuration (using s, p, d notation) for the following species

a) nitride ion $1s^2 2s^2 2p^6$

b) potassium atom $1s^2 2s^2 2p^6 3s^2 3p^1$

4. A crystal of iodine, heated gently in a test-tube, gave off a purple vapour. A crystal of sodium iodide, heated to the same temperature remained unchanged.

a) Explain the above observations in terms of structure and bonding.

- Iodine is covalent molecular with only weak forces of attraction between its molecules (1mk)
- Sodium iodide is an ionic substance with strong forces of attraction between ions throughout the lattice (1mk)
- Sodium iodide needs more energy to separate its particles and allow a phase change to occur (1mk)

(3 marks)

b) Give the formula for the species responsible for the purple colour.

$I_2(g)$ (1 mark)

5. Pure water undergoes self-ionisation according to the following equilibrium:

$2H_2O(l) \quad \leftrightarrow \quad H_3O^+(aq) \quad + \quad OH^-(aq)$

The equilibrium constant for the ionisation of water (K_w) is 1.0×10^{-14} at 25ºC

Write the equilibrium constant expression for this reaction.

$K = [H_3O^+][OH^-]$

As the temperature is decreased the value of K_w decreases.

Is pure water acidic, basic or neutral at 10ºC? Explain your answer.

Neutral (1mk)
The concentration of H^+ ions is still equal to the concentration of OH^- even though the temp has changed and hence water is still neutral (1mk)

(2 marks)

6. Consider the 0.1 mol L^{-1} solutions of:

Sodium hydroxide
Ammonium chloride
Sulfuric acid
Ethanoic(acetic) acid

a) Which solution would have the lowest electrical conductivity? Explain your answer.

Acetic acid is the only weak electrolyte (because it only partially ionises in solution) and hence it has the lowest electrical conductivity because it has the lowest total concentration of ions (3mk)

b) Which solution would have the highest pH? Explain your answer.

NaOH (1mk) the most basic substance has the highest pH and this is the only strong base on the list (1mk)

c) Which solution would have the highest total concentration of ions?

H_2SO_4 (1mk)

7. Consider the following chemical substances.

PCl_3, SiO_2, $SiBr_4$, F_2, CS_2, BeH_2, NH_4I, HCOOH

List all the non polar molecules	F_2 CS_2 BeH_2 $SiBr_4$
List the molecules which would have hydrogen bonds between them	HCOOH
List the pyramid-shaped molecules	PCl_3

(6 marks)

8. Write equilibrium constants for the following chemical equilibria:

a) $TiO_2(s) + 2\ Cl_2(g) + 2\ C(s) \leftrightarrow TiCl_4(g) + 2\ CO(g)$

b) $[Fe(H_2O)_6]^{3+}(aq) + 6\ SCN^-(aq) \leftrightarrow [Fe(CN)_6]^{3-}(aq) + 6H_2O(l)$

a)
$K = \frac{[TiCl_4][CO]^2}{[Cl_2]}$

b)
$K = \frac{[Fe(CN)_6^{3-}]}{[Fe(H_2O)_6^{3+}][SCN^-]^6}$

(2 marks)

9. Calcium carbonate decomposes when heated

$$Energy + CaCO_{3(s)} \leftrightarrow CaO_{(s)} + CO_{2(g)}$$

If the mixture is present in a closed container equilibrium will be established.

Predict the effect of the following changes on the concentration of carbon dioxide at equilibrium and explain your predictions.

Change Imposed	Effect on conc of $CO_{2(g)}$	Explanation
The pressure inside the container is increased by reducing the volume of the container	No change	Initially there is a sudden increase in[CO2] and then the reverse reaction is favoured to re-establish equilibrium and so [CO2] is restored to original level Because in this case K=[CO2]
Helium gas is added	No change	Helium gas particles do not participate in reaction and so neither forward or reverse reaction rate is affected and equilibrium is undisturbed
A small quantity of $CaCO_{3(s)}$ is added	No change	Amount of solid does not affect rate of forward or reverse reaction and so equilibrium is undisturbed

(9 marks)

10. Describe briefly a chemical test and observations by which you could distinguish between the following pairs of chemical substances. Equations are not necessary.

Substances	Test	Observations
Ba(NO3)2 and Pb(NO3)2	Add solution sodium hydroxide	The lead nitrate solution will form a white precipitate
Solid silver chloride and solid silver carbonate	Add hydrochloric acid to both	The silver carbonate will produces bubbles, the silver chloride will not

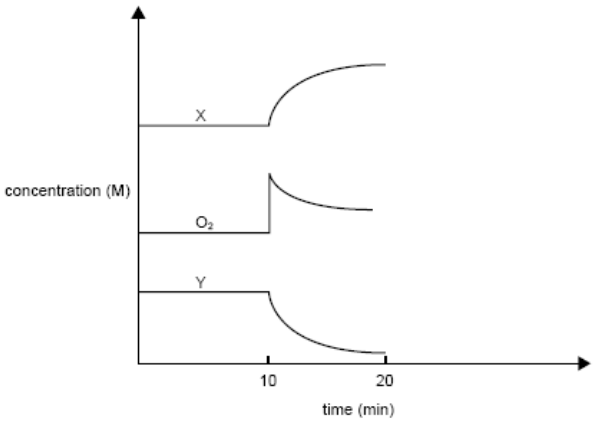
(4 marks)

11. Part of the Contact process for the manufacture of sulphuric acid involves the conversion of sulfur dioxide to sulfur trioxide as shown by the following equation

$$2SO_2(g) + O_2(g) \leftrightarrow 2SO_3(g) \quad \Delta H = -192 kJmol^{-1}$$

In a study of this process, a container was filled with an equilibrium mixture of sulfur dioxide, sulfur trioxide and oxygen in the presence of a catalyst. The container was initially at 450°C and was very well insulated.

An experiment was conducted on the container and the concentrations during the experiment are shown on the graph below:



a) What change was imposed on the system at the 10 minute point? (1 mark)

some oxygen gas was added to the mixture

b) Which components of the equilibrium mixture are represented by the lines labelled X and Y?

X SO_3

Y SO_2 (2 marks)

c) Give explanations for the changes in concentration that occur in X, Y and O_2 between 10 and 20 minutes

the increase in conc of O2 means increase in forward rate (1mk)
because of increase in collisions between O2 and SO2 (1mk)
this means conc of SO3 increases and O2 and SO2 decreases until equilibrium is re-established (1mk) (3 marks)

d) Would the temperature of the mixture increase, decrease or remain the same between 10 and 20 minutes? Explain your answer

increase (1mk)
the forward reaction is exothermic and it is the one favoured during this period of time (1mk)
system not likely to lose too much heat as it is well insulated (1mk)
(3 marks)

Part Three Calculations

1. a) $3Ba^{2+}(aq) + 2PO_4^{3-}(aq) \rightarrow Ba_3(PO_4)_2(s)$ (2mk) doesn't have to be ionic

b) $3\ BaCl_2 + 2Na_3PO_4 \rightarrow 6NaCl + Ba_3(PO_4)_2$

$n = cv$

$= (0.145)(0.05) = 7.25 \times 10^{-3}$ (1mk)

$nBa_3(PO_4)_2 = ½ \times Na_3PO_4$ (1mk)

$= ½ \times 7.25 \times 10^{-3}$

$= 0.003625M$ (1mk)

$massBa_3(PO_4)_2 = 0.003625 \times (3 \times 137.3 + 2x30.97 + 8x16)$

$= 0.003625 \times 601.84 = 2.18g$ (1mk)

c) $nNa^+ = 3 \times nNa_3PO_4 = 3 \times 7.25 \times 10^{-3} = 0.02175mol$ (1mk)

$v_T = 100mL$ (1mk)

$c = n/v = 0.02175/0.1 = 0.218M$ (1mk)

2. If 50mL of water is added to 25mL of 2M H_2SO_4 what will be the pH of the resulting solution? (4 marks)

$nH_2SO_4 = cv = (2)(0.025) = 0.05mol$ (1mk)

$v_T = 50 + 25 = 75mL = 0.075L$ (0.5mk)

$cH_2SO_4 = n/v = 0.05/0.075 = 0.667M$ (1mk)

$[H^+] = 2 \times 0.667 = 1.333M$ (1mk)

$pH = -\log [H+] = -\log (1.33) = 0.125$ (0.5mk)

3.

a) $SiO_2 + 3C \rightarrow SiC + 2CO$ (1mk)

b) $125600/28.09 + 2x16 = 125600/60.09 = 2090.2$ mol (1mk)

$63500/21.01 = 5287.3mol$ (1mk)

Need ratio $SiO_2/C = 1/3 = 0.33/1$

Given ratio $SiO_2/C = 2090.2/5287.3 = 0.395/1$

Therefore LR is C (1mk)

c) $nSiC = 1/3 \times nC = 1/3 \times 5287.3 = 1762.4$ (1mk)

$mass\ SiC = 1762.4 \times 40.1 = 70672g = 70.6kg$ (1mk)

d) $nSiO_2$ used $= 1/3 \times nC = 1762.4mol$

moles SiO_2 leftover $= 2090.2-1762.4 = 327.8mol$ (1mk)

mass SiO_2 leftover $= 327.8 \times 60.09 = 19.7\ kg$ (1mk)

4. a) i) mass $ZnSO_4$ = 2.086g

$nZnSO_4$ = 2.086/65.38 + 32.06 + 4x16 = 2.086/161.44 = 0.01292mol (1mk)

ii) mass H_2O lost = 3.715 – 2.086 = 1.629g (1mk)

moles H_2O lost = 1.629/18.016 = 0.0904mol (1mk)

(iii)

	$ZnSO_4$	H_2O
moles	0.01292	0.0904
ratio	0.01292/0.01292= 1	0.0904/0.01292= 7

X = 7 (1mk)

b) i) Zn = 0.015g needed

nZn needed = 0.015/65.38 = 0.0002294mol (1mk)

$nZnSO_4.7H_2O$ needed = 0.0002294mol (1mk)

mass $ZnSO_4.7H_2O$ needed = 0.0002294 x (287.552) = 0.066g (1mk)

ii) c = n/v = 0.0002294/0.005 = 0.0459M (2mk)

5.

	Rough	1	2	3	4
Final Volume (mL)	42.6	38.10	32.55	45.10	38.75
Initial Volume (mL)	10.0	5.65	2.05	12.70	6.35
Titre (mL)	32.6	32.45	30.5	32.4	32.4

a. i) average titre= 32.45 + 32.40 + 32.40/3 = **32.42** mL(or **32.40** mL using two values)

$n(OH^-)$ = cV = 0.121 x 0.03242 = **3.922×10^{-3} mol** (3.920×10^{-3} mol)

n(H+) in 25.00 mL = **3.922×10^{-3} mol** (3.920×10^{-3} mol)

c(HCl) = n/V = 0.1569 = **0.157 mol L-1 HCl**

ii) n(HCl) = cV = 0.1569 x 4000 = **628 mol** (627 mol)

b. i) $Ca(OH)_2(s) + 2H^+(aq) \rightarrow Ca^{2+}(aq) + 2H_2O(l)$

ii) $n(Ca(OH)_2)$ = n(limestone, $CaCO_3$) = ½ n (HCl) = **313.8 mol** (313.6)

$m(Ca(OH)_2)$ = nM = 313.8 x 100.009 = **31407.6 g**

actual mass required **100/92.3** x 31407.4 = 34.03 kg

5. a)

	C	H	N	O
%	68.15	6.87	0.177/1.112 x 100 = 15.9 (1mk)	100 – 90.92 = 9.08 (1mk)
g/100g	68.15	6.87	15.9	9.08
mole	68.15/12.01 = 5.674 (0.5mk)	6.87/1.008= 6.815 (0.5mk)	15.9/14.01= 1.135 (0.5mk)	9.08/16= 0.5675 (0.5mk)
ratio	5.674/0.5675= 10	6.815/0.5675= 12	1.135/0.5675= 2	0.5675/0.5675= 1 (1mk)

EF is $C_{10}H_{12}N_2O$

b) EF mass is (10 x 12.01) + (12 x 1.008) + (2 x 14.01) + 16 = 176.2 (1mk)

PV = nRT
(106.3)(0.633) = n(8.315)(428)

n = 0.0189mol (1mk)

n= mass/molar mass
0.0189 = 3.33/molar mass

Molar mass = 176.2 (1mk)

Molar mass/EF mass = 1 therefore molecular formula is $C_{10}H_{12}N_2O$ (1mk)

The following table contains information about the melting points and conductivities of some substances.

Compound	Melting point (°C)	Electrical Conductivity in aqueous solution	Electrical Conductivity in the liquid state
Methylbutane $CH_3CH_2(CH_3)CH_2CH_3$	-160	n/a	very low
silicon	1410	n/a	very low
cobalt	1495	n/a	very high
ethanoic acid (CH_3COOH)	17	moderate	low
water	0	low	low
sulfur (S_8)	113	n/a	very low
lithium sulfide	900	high	high

Discuss the forces between the particles involved in solid samples of each of the substances, and so account for their melting points and conductivities.

Quick plan