



CHEMISTRY

Stage 3

Aquinas College Semester 1 Examination, 2013

Question/Answer Booklet

Name: _____

Student Number: In figures

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TIME ALLOWED FOR THIS EXAMINATION

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

Materials required

To be provided by the supervisor

This Question/Answer Booklet
Multiple-choice Answer Sheet
Chemistry Data Sheet

To be provided by the candidate

Standard items: pens, pencils, pencil sharpener, eraser, correction fluid/tape, ruler, highlighters
Special items: non-programmable calculators satisfying the conditions set out by the Curriculum Council for this course

Important note to candidates

No other items may be used in this examination. 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

Section	Number of questions available	Number of questions to be answered	Suggested working time (minutes)	Marks available	Percentage of exam
Section One: 25 Multiple-choice	25	25	50	50	25%
Section Two: 12 Short answer	9	9	60	70	35%
Section Three: 6 Extended answer	8	8	70	80	40%
				100	100%

Instructions to candidates

The rules for the conduct of Western Australian external examinations are detailed in the *Year 12 Information Handbook 2012*. Sitting this examination implies that you agree to abide by these rules. Answer the questions according to the following instructions.

Section One: Answer all questions on the separate Multiple-choice Answer Sheet provided. For each question shade the box to indicate your answer. Use only a blue or black pen to shade the boxes. If you make a mistake, place a cross through that square, do not erase or use correction fluid, and shade your new answer. Marks will not be deducted for incorrect answers. No marks will be given if more than one answer is completed for any question.

Sections Two and Three: Write answers in this Question/Answer Booklet.

When calculating numerical answers, show your working or reasoning clearly unless instructed otherwise. **Answer all questions to 3 significant figures.**

You must be careful to confine your responses to the specific questions asked and to follow any instructions that are specific to a particular question.

Spare pages are included at the end of this booklet. They can be used for planning your responses and/or as additional space if required to continue an answer.

- Planning: If you use the spare pages for planning, indicate this clearly at the top of the page.
- Continuing an answer: If you need to use the space to continue an answer, indicate in the original answer space where the answer is continued, i.e. give the page number. Fill in the number of the question(s) that you are continuing to answer at the top of the page.

Section One: Multiple-choice**25% (50 Marks)**

This section has **25** questions. Answer **all** questions on the separate Multiple-choice Answer Sheet provided. For each question shade the box to indicate your answer. Use only a blue or black pen to shade the boxes. If you make a mistake, place a cross through that square, do not erase or use correction fluid, and shade your new answer. Marks will not be deducted for incorrect answers. No marks will be given if more than one answer is completed for any question.

Suggested working time for this section is 50 minutes.

1. For the substances C (graphite), N₂, C₃H₈ and C₂H₅OH, which of the following correctly represents them in order of increasing melting point?

- a) N₂, C₃H₈, C₂H₅OH, C
- b) N₂, C, C₃H₈, C₂H₅OH
- c) N₂, C, C₂H₅OH, C₃H₈
- d) C₃H₈, N₂, C₂H₅OH, C

2. Which one of the following observations can be explained in terms of hydrogen bonding?

- a) The boiling point of H₂S is greater than that of PH₃.
- b) The melting point of CH₃F is less than that of PH₃.
- c) The boiling point of CH₃NH₂ is greater than that of H₂S.
- d) The melting point of HI is greater than that of NH₃.

3. The symbols and respective electronegativities for elements in a hypothetical universe are given in the table to the right:

Element	Electronegativities
L	2.0
M	3.5
Q	0.9
R	2.5

Which of the following bonds is *least* polar?

- a) M-L
- b) Q-M
- c) L-R
- d) M-R

4. Which of the following has the substances listed in the correct order of increasing strength of the intermolecular forces within the substance?

- a) H₂ < CO₂ < NH₃ < HCl
- b) H₂ < CO₂ < HCl < NH₃
- c) CO₂ < HCl < NH₃ < H₂
- d) H₂ < HCl < CO₂ < NH₃

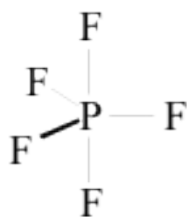
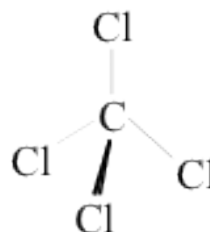
5. An element has the following five successive ionisation energies (in kJ mol⁻¹)

502, 4569, 6919, 9550, 13356

What would be the formula of the compound formed when X reacts with sulphur?

- a) X_2S
- b) XS
- c) XS_2
- d) X_2S_3

6. Molecules of the compounds carbon disulfide, carbon tetrachloride, phosphorus pentafluoride and hydrogen chloride can be represented by the following diagrams:



Which of these compounds are polar molecules?

- a) All of the molecules are polar.
- b) Hydrogen chloride only.
- c) Hydrogen chloride and phosphorus pentafluoride.
- d) All of the above except carbon disulfide.

7. A sea water sample was collected near the waste outlet from a metal refinery. 1.00 kg of the sea water occupied 970 mL and was found to contain 2.00 mg of lead present as $Pb^{2+}_{(aq)}$.

Which of the following is the incorrect expression for the concentration of lead in the sea water sample?

- (a) 9.65 ppm (parts per million)
- (b) 2.06 mg L⁻¹
- (c) 2.00 x 10⁻⁴ g per 100 g
- (d) 9.95 x 10⁻⁶ mol L⁻¹

8. Given the reaction: $CH_{4(g)} + 2O_{2(g)} \rightleftharpoons CO_{2(g)} + 2H_2O_{(l)} + \text{heat}$

Which procedure will make the equilibrium shift to the right?

- (a) add an inert gas
- (b) decrease temperature
- (c) increase the volume
- (d) decrease the partial pressure of $O_{2(g)}$

9. Consider the following substances in the molten (liquid) state:

- | | |
|------------|----------------|
| <i>I</i> | $C_{10}H_{22}$ |
| <i>II</i> | NH_3 |
| <i>III</i> | CH_3Cl |
| <i>IV</i> | N_2 |

Which of the above substances have only dispersion forces between their molecules?

- (a) None of the above
- (b) II and IV only
- (c) II and III only
- (d) I and IV only

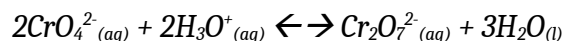
10. A compound has the empirical formula CH_2O . If 3.50 g of the gaseous compound occupied 436 mL at STP, which of the following is the molecular formula of the compound?

- (a) CH_2O
- (b) $C_3H_6O_3$
- (c) $C_4H_8O_4$
- (d) $C_6H_{12}O_6$

11. Which of the following compounds is most soluble in petrol whose formula may be represented as $C_8H_{18}(l)$:

- (a) $CH_3(CH_2)_7OH(l)$
- (b) $C_7H_{16}(l)$
- (c) $HCl(g)$
- (d) $CH_3COOH(l)$

12. The chromate-dichromate equilibrium is given by the following reaction:



In order to shift this equilibrium to the left, one should add:

- a) $\text{H}_2\text{SO}_4(\text{l})$
- b) $\text{NaOH}(\text{s})$
- c) $\text{HCl}(\text{g})$
- d) $\text{K}_2\text{CrO}_4(\text{s})$

13. Which of the following is true for a system at equilibrium?

- a) The number of collisions per unit time between reactants is equal to the number of collisions per unit time between the products.
- b) The product of the concentrations of the reactants is equal to the product of the concentrations of the products.
- c) Reactants are reacting to form products at the same rate as products are reacting to form reactants.
- d) All concentrations of reactants and products are equal

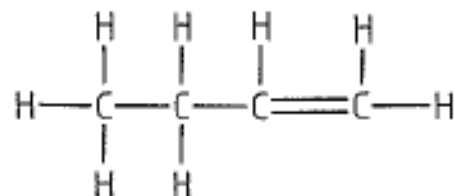
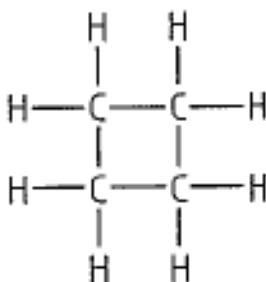
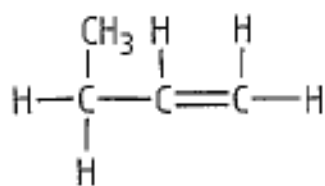
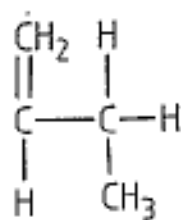
14. Which of the following represents 2-methyl-1-butanol?

- a. $\text{CH}_3\text{CH}_2\text{CHCH}_3\text{CH}_2\text{OH}$
- b. $\text{CH}_3\text{CCH}_3\text{OHCH}_3$
- c. $(\text{CH}_3)_2\text{CCH}_2\text{CH}_2\text{OH}$
- d. $\text{CH}_3\text{C}(\text{CH}_3)_2\text{CH}_2\text{OH}$

15. A sample of 1-propanol is treated with limited acidified potassium dichromate solution. Which of the following species would NOT be present in the final mixture?

- a. propanol
- b. 1-propanol
- c. propanoic acid
- d. propanone

16. Consider the following structures. How many different isomers of C_4H_8 are shown here?

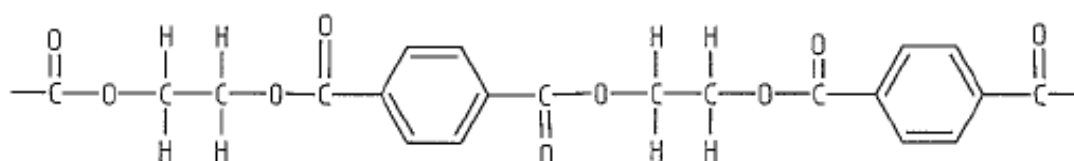


- (a) 1
(b) 2
(c) 3
(d) 4

17. What are the product(s) when ethene gas is bubbled through a bromine water solution?

- (a) 1,2-dibromoethane
(b) 1,1-dibromoethane
(c) 1,2-dibromoethene and hydrogen bromide
(d) 1,2-dibromoethane and hydrogen bromide

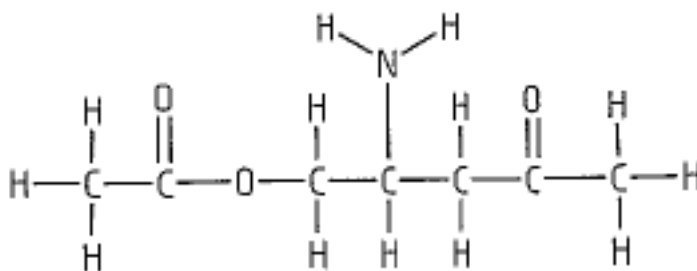
18. The structure below shows a small section of a polymer



Which of the following best describes the type of reaction used to produce this polymer?

- (a) Addition polymerisation
(b) Substitution polymerisation
(c) Esterification polymerisation
(d) Condensation polymerisation

19. Which list correctly names the functional groups shown in the following structure?

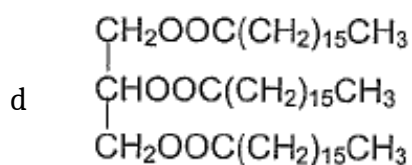
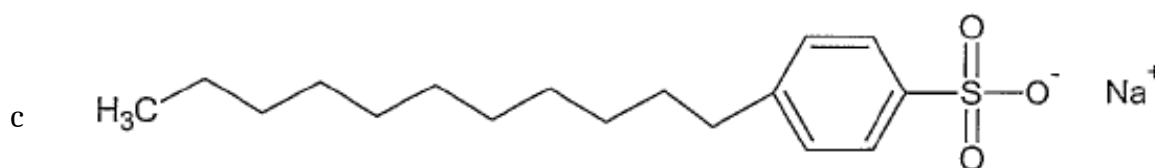
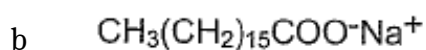
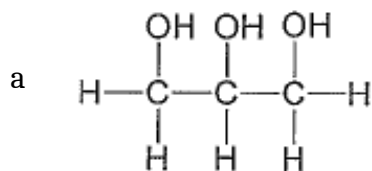


- | | | |
|---------------------|----------------------|----------|
| (a) ester | α -amino acid | ketone |
| (b) carboxylic acid | α -amino acid | ketone |
| (c) carboxylic acid | amine | aldehyde |
| (d) ester | amine | ketone |

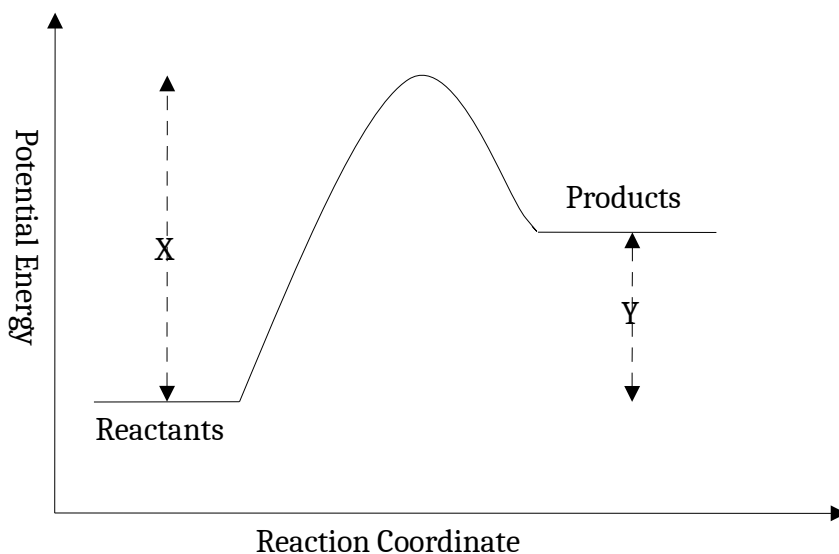
20. When 40 mL of 1.0 mol L⁻¹ Ba(NO₃)₂ solution is added to 10 mL of 2.0 mol L⁻¹ K₂SO₄ solution, the amount in moles of BaSO₄ precipitate formed is:

- (a) 1.0 mol
 (b) 0.020 mol
 (c) 0.060 mol
 (d) 0.040 mol

21. Which of the following represents the structure of a soap?



22. Consider the following potential energy diagram for a chemical reaction:



Which one of the following statements about this reaction is incorrect?

- a) The reaction mixture will become hotter as the reaction proceeds.
- b) The activation energy for the reverse reaction is X minus Y.
- c) The ΔH for the reverse reaction is $-Y$.
- d) The forward reaction rate is likely to be slower than the reverse reaction rate

23. What volume of carbon dioxide (measured at the original temperature and pressure) is produced when 100mL of ethene, $C_2H_4(g)$, is burnt according to the equation:



- (a) 50mL.
- (b) 100mL.
- (c) 200mL.
- (d) 300mL.

24. Which of the following would not be expected to discolour a solution of acidified potassium permanganate solution?

- (a) CH_3CH_2OH
- (b) CH_3CH_2CHO
- (c) CH_3COCH_3
- (d) $CH_3CHOHCH_3$

25. Which one of the following trends occurs as the atomic number increases for the Group 17 elements?

- (a) atomic radii decrease
- (b) melting point decreases
- (c) the tendency to gain electrons decreases
- (d) the elements become more reactive

END OF SECTION 1

Section Two: Short answer**35% (70 Marks)**

This section has **9** questions. Answer **all** questions. Write your answers in the space provided. Spare pages are included at the end of this booklet. They can be used for planning your responses and/or as additional space if required to continue an answer.

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Suggested working time for this section is 60 minutes.

Question 26**(18 marks)**

(a) (i) What is the VSEPR hypothesis? _____

[1M]

(ii) Carbon tetrafluoride and phosphorus trihydride molecules have four electron pairs around the central atom. However, the shape and bond angles of both molecules are different. Explain how the VSEPR hypothesis can be used to determine the difference in the shapes and bond angles.

[2M]

(b) For each of the following pairs of compounds, state which compound has the higher boiling point and indicate the type of Van der Waals force responsible for the difference between the boiling points. [4M]

Pairs of substances	Higher boiling substance	Intermolecular force responsible for the difference
F ₂ and Cl ₂		
CH ₃ CH ₂ OH and CH ₃ CH ₂ NH ₂		
CH ₃ (CH ₂) ₁₀ OH and CH ₃ OH		
Br ₂ and ICl		

(c) Write a brief paragraph to explain each of the following observations, giving examples or diagrams where appropriate to illustrate your answer

(i) When metals are hit with a hammer, it usually leaves an impression on the surface but glass and diamond will shatter

_____ [2M]

(ii) Explain in terms of intermolecular forces why methylated spirits (mainly ethanol) is more effective than water for removing grease from clothing

_____ [3M]

(d) For each of the species listed in the table below, draw the electron dot structure, representing all valence shell electron pairs as : or – **and** state or draw the shape of the molecule or ion.

[6M]

Species	Electron Dot Structure (showing all valence shell electrons)	Shape
CO_3^{2-}		
CHI_3		
$\text{Mg}(\text{NO}_3)_2$		

Question 27**(10 marks)**

A particular cryogenic distillation plant produces liquid oxygen at a rate of 310 L per hour.

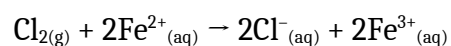
(a) Assuming all of the processes are 100% efficient, and the density of liquid oxygen is $1.15 \times 10^6 \text{ g L}^{-1}$, what volume of air, at a pressure of 101.3 kPa and 20°C, would be required by the plant in a 24-hour period? Assume oxygen content in air is 21% [3M]

(b) The oxygen produced in these plants is often stored under a pressure of $1.55 \times 10^4 \text{ kPa}$, at 20°C, in gas cylinders to be used for oxygen therapy and resuscitation. If each of these cylinders has a volume of 680 L, how many cylinders could be filled with oxygen in 1 hour? [2M]

Question 28**(5 marks)**

(a) If 200 mL of 0.256 mol L⁻¹ sodium chloride solution is mixed with 150 mL of 0.166 mol L⁻¹ sodium sulfate solution, what is the concentration of sodium ions in the resulting solution? [2M]

(b) When chlorine is bubbled into a freshly prepared solution of iron(II) sulfate, chloride ions and iron(III) ions are formed according to the equation:



If 0.280 L of chlorine, measured at a temperature of 24.0°C and 125 kPa pressure, is bubbled into 140 mL of a 0.396 mol L⁻¹ iron(II) sulfate solution, what will be the concentration of Fe³⁺ in the newly formed solution? (Assume the volume of the solution does not change during the reaction.)

[3M]

Question 29**(7 marks)**

- (a) Draw structural formulae for the primary and secondary alcohols of molecular formula C_3H_8O . (2M)

Primary	Secondary

- (b) One of the above isomers is treated with acidified potassium permanganate. The resulting organic product is isolated and, when tested with sodium hydrogencarbonate solution, the mixture fizzes, producing a colourless gas. Draw the structural formula of this organic product.

Organic product	(1M)

- (c) Draw a structural formula for any other isomer of C_3H_8O that is different to your answer from part a.

	(1M)

- (d) Write a balanced oxidation half equation, reduction half equation and overall redox equation for the addition of acidified potassium permanganate to propanal. (3M)

Oxidation half equation

Reduction half equation

Redox equation

Question 30

(4 marks)

- (a) The aroma of rockmelon is largely due to the ester methyl butanoate. Draw the structure for this organic compound, showing all atoms. (1M)

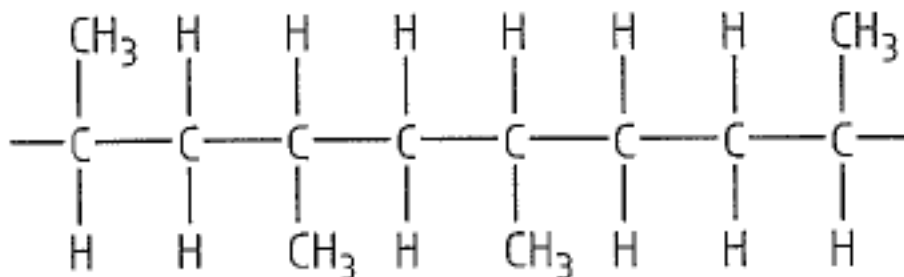
- (b) This substance can be prepared in the laboratory by a simple esterification reaction. Name the two organic compounds that could be used to prepare this ester. (2M)

_____ and _____

- (c) One of the isomers of methyl butanoate is an unbranched carboxylic acid. Name this isomer. (1M)

Question 31**(5 marks)**

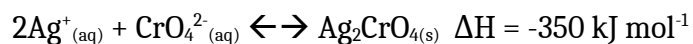
The following diagram shows part of a polymer molecule.



- (a) Name the type of polymerisation process involved in forming this polymer. (1M)
- (b) Distinguish between the terms monomer and polymer using the above to illustrate your answer. (2M)
- (c) Sketch a section of the polymer formed from the polymerisation of chloroethene. Include four monomer units in your sketch. (2M)

Question 32**(5 marks)**

Ag_2CrO_4 is a slightly soluble salt and forms a saturated solution. This can be expressed according to the following equation:



Predict and explain the effect on the equilibrium after the following changes have been applied:

(a) A few drops of concentrated NaCl solution is added to the system [1M]

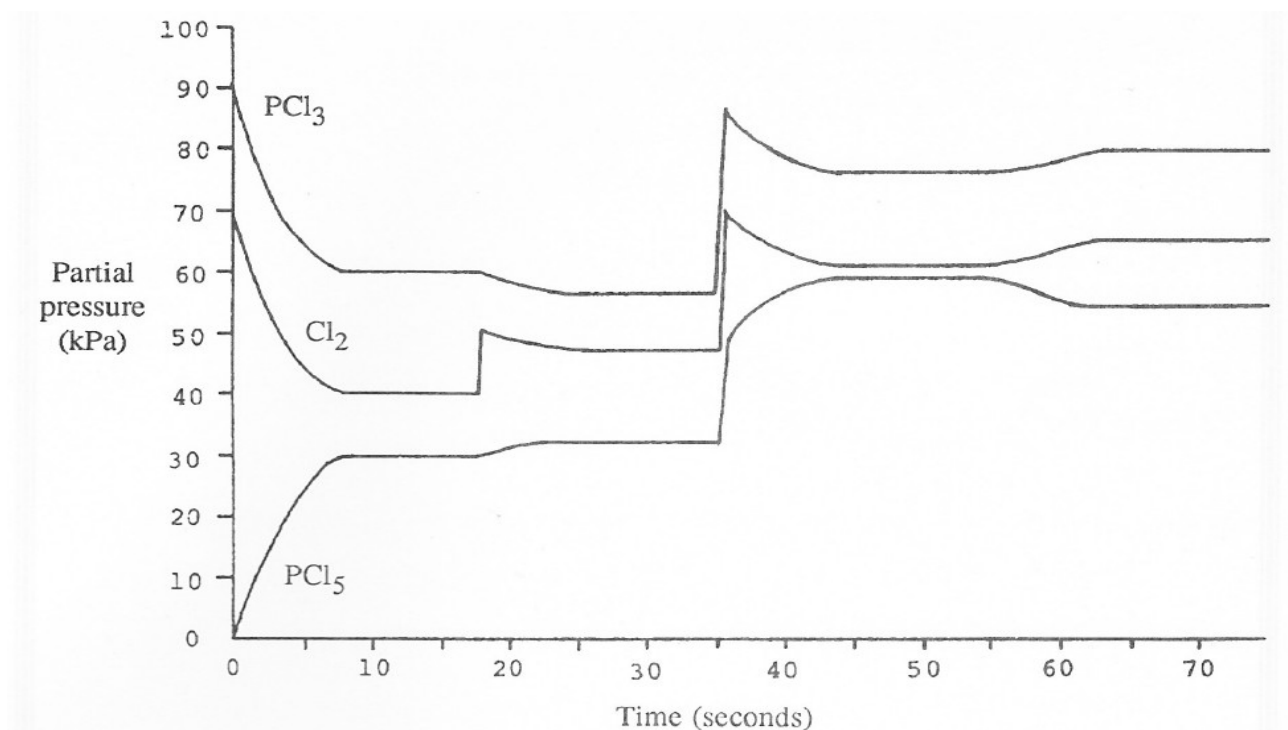
(b) The solution is diluted by the addition of a small amount of water [1M]

(c) Some solid Ag_2CrO_4 is added to the system [1M]

(e) Draw and label a potential energy curve for the above reaction. Given the activation energy is 250kJ [2M]

Question 33**(12 marks)**

The following diagram shows how the concentration (given as partial pressures in kPa) of the gases PCl_3 , Cl_2 and PCl_5 varied with time in a reaction container. Heat is produced by this reaction.



(a) Write an equilibrium equation for the reaction occurring. [1M]

(b) Describe the main process occurring during the first five seconds. [2M]

(c) What occurred at $t = 17$ seconds? Explain how you reached this conclusion. [2M]

(d) State and explain what is occurring in the reaction vessel during the period $t = 18$ seconds to $t = 25$ seconds. [2M]

(e) What occurred at $t = 35$ seconds? [1M]

(f) State and explain what is happening during the period $t = 36$ secs to $t = 45$ secs? Explain your answer. [2M]

(g) What happened to the system at $t = 55$ seconds? Give reasons for your answer. [2M]

Question 34**(4 marks)**

Write ionic equations for the reaction that occurs in each of the following. If no reaction occurs, write 'no reaction'.

(i) Sodium hydrogen carbonate solid is mixed with hydrochloric acid solution. [2M]

(ii) Barium nitrate solution is mixed with sodium sulfate solution. [2M]

END OF SECTION 2

Section Three: Extended answer**40% (80 Marks)**

This section contains **eight (8)** questions. You must answer **all** questions. Write your answers in the space provided.

Spare pages are included at the end of this booklet. They can be used for planning your responses and/or as additional space if required to continue an answer.

- Planning: If you use the spare pages for planning, indicate this clearly at the top of the page.
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Suggested working time for this section is 70 minutes.

Question 35**(8 marks)**

When copper (II) sulphate is dissolved in water a blue coloured solution of $\text{Cu}^{2+}_{(\text{aq})}$ ions are formed and when treated with excess concentrated ammonia solution the initial precipitate of copper hydroxide dissolves to give a deep blue solution. When ethanol is added to the solution, deep blue crystals precipitate. When the solution is filtered the crystals smell of ammonia, and an unstable salt with the formula $\text{Cu}(\text{NH}_3)_x\text{SO}_4 \cdot y\text{H}_2\text{O}$ has been formed.

- (a) When 1.4009g of the unstable salt is heated at 300°C , the salt decomposes and the ammonia is driven off. The ammonia that is produced is captured and found to occupy 539.1mL at 250°C and 104.5 kPa. Calculate the number of moles of ammonia in the 1.4009g sample of the complex salt. [2M]

(b) Calculate the mass of the ammonia in the 1.4009g sample. [2M]

(c) Another 1.4009g sample of the unstable salt is heated at 300°C driving all off the ammonia and water leaving only 0.9055g of copper(II) sulphate behind. Calculate the mass of water in a 1.4009g sample of the unstable salt. [2M]

- (d) Calculate the number of moles of water in a 1.4009g sample of the unstable salt. [1M]
- (e) Calculate the number of moles of copper (II) sulphate in the 0.90551g sample of copper sulphate. [1M]

Question 36**(10 marks)**

The nitrogen content of a 0.895 g sample of dried protein was determined by converting all the nitrogen in the protein into ammonia gas. The ammonia was then bubbled through 50.0 ml of 0.1970 mol L⁻¹ hydrochloric acid causing a reaction to occur between the two species. After the ammonia had reacted there was some hydrochloric acid remaining. This was neutralised by reacting with exactly 5.90 ml of 1.028 mol L⁻¹ sodium hydroxide solution. Calculate the percentage by mass of nitrogen in the sample of dried protein. In this question marks will be allocated for chemical equations shown.

[10M]

Question 37

(12 marks)

- (a) Contrary to expectations, the size of an atom as measured by its atomic radius does not simply increase as the number of subatomic particles in the atom increases.

Explain this statement

[6M]

[illegible]

- (b)** Using three examples of your choice, explain the following statement. Use relevant bonding diagrams in your answer.

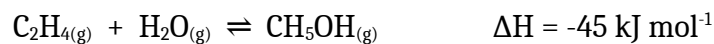
“There is a continuum from pure covalent bonding, through polar covalent bonding, to ionic bonding”

[6M]

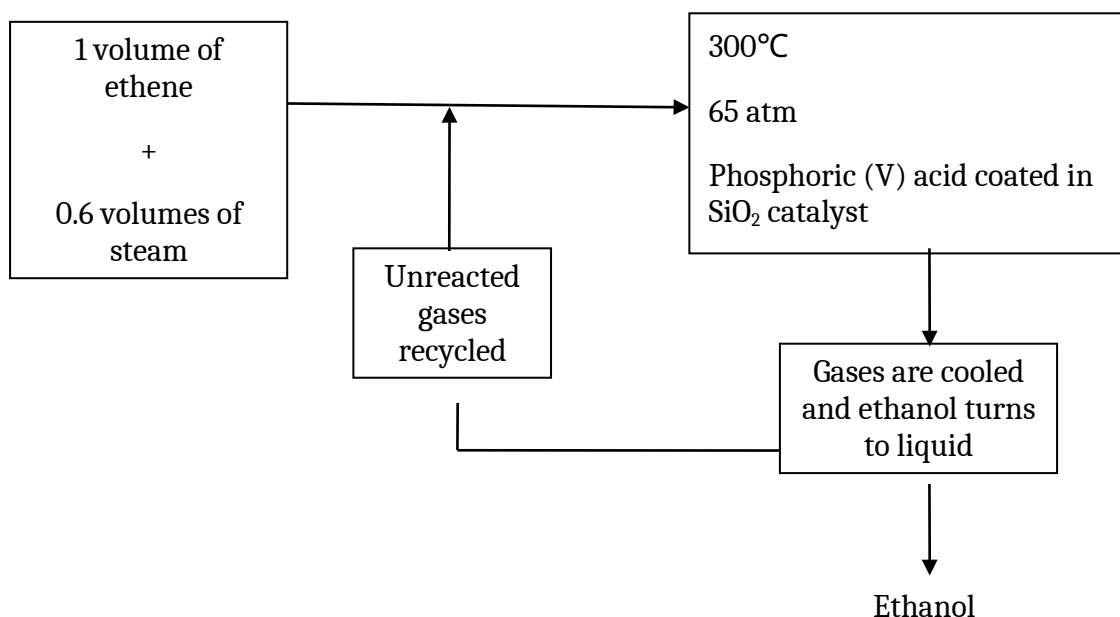
[illegible]

Question 38**(20 marks)**

The industrial production of ethanol is an increasingly important process. The equation for this reaction is:



A flow chart for the reaction looks like this:



(a) State and explain the ideal conditions for increased rate of the formation of ethanol. [2M]

(b) State and explain the ideal conditions for increased yield of ethanol. [2M]

- (c) Explain the compromises made, and the reasons for these, in the actual conditions used in the industrial production of ethanol. [2M]

- (d) Catalysts are used in this process. State and explain their function in industrial processes with the aid of an energy profile diagram. [3M]

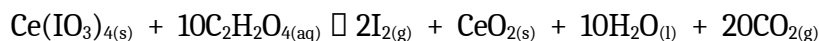
- (e) Using the collision theory explain why it is important to remove the ethanol from the system and add more reactants as well as recycling the unreacted gases [3M]

- (f) Theoretically what mass of ethanol is produced from 10 000L of ethene at the conditions listed above? [6M]

- (g) Theoretically if 350L of ethanol were produced what is the % efficiency of the process [2M]

Question 39**(13 marks)**

A chemist wants to determine the percentage of cerium(III) and cerium(IV) in a sample containing $\text{Ce}(\text{NO}_3)_3$, CeCl_4 as well as some non-cerium impurities. He dissolves 2.167 grams of the sample in water and adds potassium bromate to oxidise all cerium(III) to cerium(IV). Enough potassium iodate is then added to precipitate out the cerium(IV) as cerium(IV) iodate, $\text{Ce}(\text{IO}_3)_4$. He collects the solid by filtration and places the solid with its filter paper into a beaker. To this he adds a quantity of oxalic acid, $\text{C}_2\text{H}_2\text{O}_4$, in order to remove iodine from the system. The chemical reaction that takes place is as follows:



The system is boiled to make sure all dissolved iodine is removed. It is then filtered to collect the solid. The solid CeO_2 is placed in an oven at 500°C to drive off any organic impurities. The solid CeO_2 is then weighed and found to have a mass of 2.312 grams.

The chemist then takes 1.528 grams of the original sample and analyses it for its nitrate content. The mass of the nitrate ion in this quantity is found to be 0.5230 grams.

- (a) Calculate the percentage by mass of cerium(III) as well as the percentage by mass of cerium(IV) in the original sample.

[11M]

- (b)** Calculate the pressure (in kPa) of iodine gas generated if it is collected during the procedure and occupies a volume of 255.4 ml at 25°C.

[2M]

Question 40**(6 marks)**

3.72 litres of carbon dioxide gas at 27°C at 154.2 kPa has 4.52 grams of sodium added to it. The sodium is ignited and reacts with the carbon dioxide according to the following equation:



Calculate the mass of sodium carbonate produced and the number of moles of excess reagent remaining after the reaction.

[6M]

Question 41**(6 marks)**

A particular ore contains 47.2% MnO_2 . What mass of the ore must be refined to produce 2.50 tonnes of pure manganese metal?

[6M]

Question 42

(5 marks)

There is a constant trade-off between rate, yield and equilibrium during the industrial production of chemical compounds. Explain this statement using one reaction from the contact process (production of sulfuric acid) as an example. [5M]

[illegible]

END OF EXAMINATION

Additional working space:

[illegible]

[illegible]

[illegible]
