



**ALL SAINTS'
COLLEGE**

Semester One Examination, 2014

Question/Answer Booklet

CHEMISTRY

Stage 3

Student Number: In figures

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In words

Time allowed for this paper

Reading time before commencing work: ten minutes
Working time for paper: three hours

Materials required/recommended for this paper

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, eraser, correction fluid/tape, ruler, highlighters
Special items: non-programmable calculators satisfying the conditions set by the School Curriculum and Standards Authority for this course

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

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

Instructions to candidates

1. The rules for the conduct of Western Australian external examinations are detailed in the *Student Information Handbook 2014*. Sitting this examination implies that you agree to abide by these rules.

2. 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 then shade your new answer. Do not erase or use correction fluid or tape. 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 your answers in this Question/Answer Booklet.

3. When calculating numerical answers, show your working or reasoning clearly. Express numerical answers to three significant figures and include appropriate units where applicable.
4. 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.
5. 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 in 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 question(s) that you are continuing to answer at the top of the page.

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

This section has **25** questions. Answer **all** questions on the Multiple-choice Answer Sheet provided. Use only 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. Marks will not be deducted for incorrect answers. No marks will be given if more than one answer is given for any question.

Suggested working time: 50 minutes.

1. Which of the following best describes the molecular shape and molecular polarity of a chloroform molecule whose formula is CHCl_3 ?
 - A. pyramidal, non-polar
 - B. tetrahedral, non-polar
 - C. pyramidal, polar
 - D. tetrahedral, polar

2. An element X has the following five successive ionisation energies (in kJ mol^{-1})

680	1600	8000	11600	14500
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What would be the formula of the compound formed when "X" reacts with oxygen?
 - A. XO
 - B. X_2O
 - C. X_2O_3
 - D. XO_2

3. Which of the following physical properties **decrease** with increasing atomic number for both the alkali metals and the halogens?

I	Atomic radius
II	Ionisation energy
III	Melting point

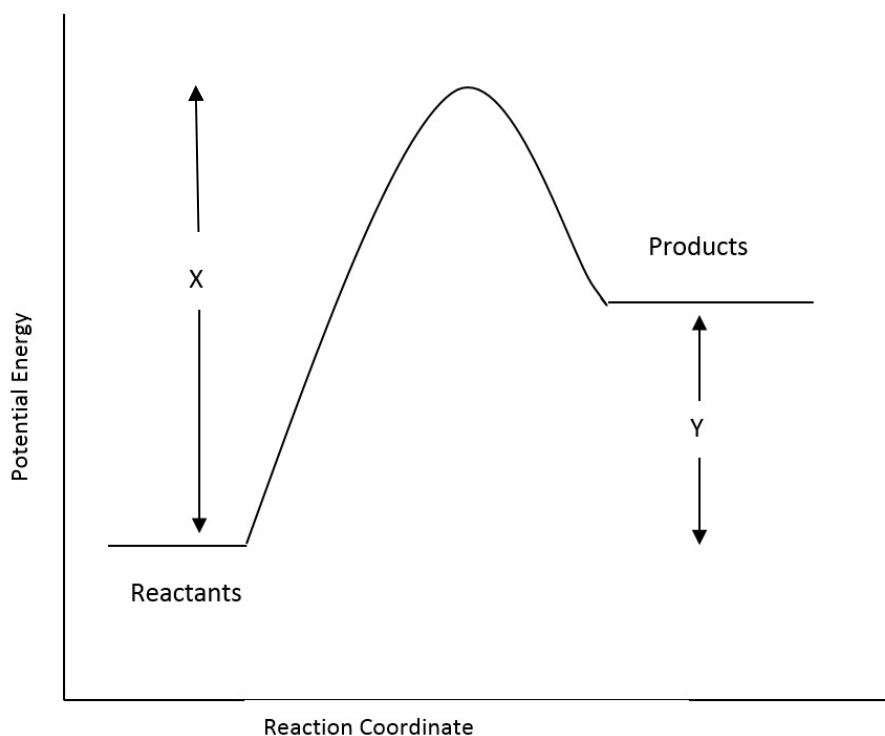
 - A. II only
 - B. I and II only
 - C. I, II and III
 - D. I and III only

4. Which one of the following solids contains ionic and covalent bonds?
- A. H_2O
B. MgO
C. NH_4Br
D. Ne
5. A crystal of iodine, I_2 , produces a purple vapour when gently heated. Which pair of statements correctly describes this process?

	<i>Type of bond broken</i>	<i>Formula of purple vapour</i>
A.	covalent	I
B.	covalent	I_2
C.	dispersion forces	I_2
D.	dipole-dipole	I_2

6. Which of the following statements is correct?
- A. Covalent network solids have strong van der Waal's forces between atoms.
B. Metal solids exhibit non-directional inter-particle bonding.
C. Ionic solids conduct electricity very well in the aqueous and solid states.
D. Covalent molecular solids tend to decompose before melting.
7. Which of the following has a different number of electrons from the other three?
- A. O_3
B. Sc^{3+}
C. C_2H_6
D. CH_3F
8. Hydrogen bromide has a low melting point because it consists of
- A. oppositely charged ions bonded by weak electrostatic attractive forces
B. positive ions electrostatically attracted to delocalised electrons
C. non-metal atoms covalently linked in a lattice
D. molecules linked by weak intermolecular attractive forces.

9. Tungsten, one of the transition metals, has a very high melting point but not as high as carbon in the form of diamond. This is best explained by:
- A. Diamond has greater dispersion forces between its atoms than tungsten.
 - B. The covalent bonding present between diamond's carbon atoms is stronger than the metallic bonding in tungsten.
 - C. Tungsten has fewer valence electrons than carbon, so the less delocalised electrons create the lower melting point.
 - D. Diamond's molecules are polar, and the dipole-dipole attraction in diamond is stronger than the metallic bonding in tungsten.
10. Consider the following potential energy diagram for a chemical reaction.

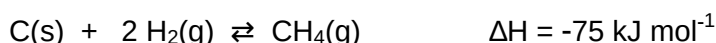


Which one of the following statements about this reaction is **incorrect**?

- A. The reaction mixture will become hotter as the reaction proceeds.
- B. The activation energy for the reverse reaction is $(X - Y)$.
- C. ΔH for the reverse reaction is $-Y$.
- D. The forward reaction rate is likely to be slower than the reverse reaction rate.

11. HCl , HBr and HI have boiling points of $-85\text{ }^{\circ}\text{C}$, $-67\text{ }^{\circ}\text{C}$ and $-35\text{ }^{\circ}\text{C}$, respectively. The best explanation for this trend in boiling points is:
- A. The strength of hydrogen bonds increases as they progress down a column of the Periodic Table.
 - B. The molecules HCl , HBr and HI show increasing polarity.
 - C. The strength of dispersion forces increases as the number of electrons in a molecule increases.
 - D. The strength of hydrogen bonds decreases as the number of electrons in a molecule increases.

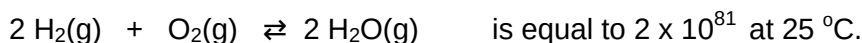
12. In the process for the preparation of methane:



If the equilibrium system temperature is increased, what effect will this have on the equilibrium constant, K , and the yield of CH_4 ?

	<i>Equilibrium constant, K</i>	<i>Yield of CH_4</i>
A.	decrease	increase
B.	decrease	decrease
C.	increase	increase
D.	increase	decrease

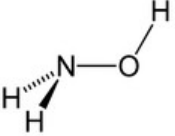
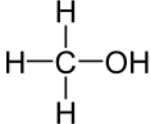
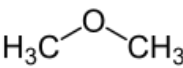
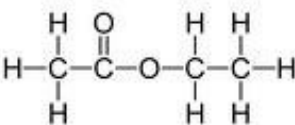
13. The equilibrium constant, K , for the reaction,



This value suggests that:

- A. this reaction favours the forward reaction slightly more than the reverse reaction.
- B. this reaction favours the reverse reaction slightly more than the forward reaction.
- C. this reaction virtually goes to completion with little reversal.
- D. this reaction virtually does not proceed forward and largely favours the reactants.

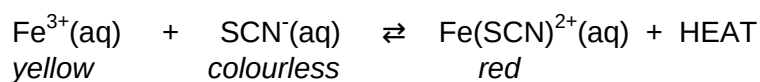
Questions 14 and 15 refer to the following four substances.

	Name	Structure
I	hydroxylamine	
II	methanol	
III	methoxymethane	
IV	ethyl ethanoate	

14. In which of the above substances would you expect hydrogen bonding to be present between their molecules?
- A. All of them
B. I, II and III
C. I and II
D. II and IV
15. Which is the only one of the above molecules that has a trigonal planar arrangement of atoms around one of the atoms in the molecule?
- A. hydroxylamine
B. methanol
C. methoxymethane
D. ethyl ethanoate

16. A row of test tubes containing iron (III) ions, thiocyanate ions (SCN^-) and the complex ion iron (III) thiocyanate ($\text{Fe}(\text{SCN})^{2+}$) are set up and allowed to come to equilibrium.

The equilibrium equation is:



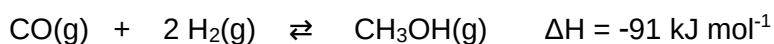
The test tubes appear orange due to the relative colours of the three ions.

Which of the following changes would **not** be expected to occur in association with the change described in the table below? (Note: AgSCN is insoluble)

	<i>Imposed change</i>	<i>Colour at the new equilibrium</i>
A.	Some $\text{NaSCN}(\text{s})$ is added and it dissolves into its ions.	Solution becomes more red.
B.	Some $\text{AgNO}_3(\text{s})$ is added, it dissolves and a white solid AgSCN forms.	Solution becomes more red.
C.	Some $\text{NaOH}(\text{s})$ is added, it dissolves and a brown solid forms.	Solution becomes more yellow.
D.	A test tube of the mixture is heated to near boiling point.	Solution becomes more yellow.

The next two questions, 17 and 18, refer to the following information:

Methanol is made commercially by pumping a mixture of carbon monoxide and hydrogen through a reaction chamber containing ZnO and Cr_2O_3 . The equilibrium equation for the reaction is:



17. Which of the following conditions would favour the highest yield of the product methanol?
- low temperature and high pressure.
 - low temperature and low pressure.
 - high temperature and low pressure.
 - high temperature and high pressure.
18. What is the likely function of the ZnO and Cr_2O_3 ?
- These conduct away the heat and help favour the forward reaction.
 - These absorb the alcohol formed so it can be evaporated off later.
 - These transition metal oxides lower the ΔH of the reaction making it go faster.
 - These may be catalysts that enable equilibrium to be achieved faster.

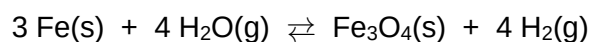
19. Consider the reaction between 1.00 g of lithium carbonate powder and 100.0 mL of 0.200 mol L⁻¹ ethanoic acid. Which of the following changes would result in an increase in the initial rate of reaction?
- Change the lithium carbonate powder to a single lump.
 - Change from 0.200 mol L⁻¹ ethanoic acid to 0.200 mol L⁻¹ hydrochloric acid.
 - Change from 100.0 mL of ethanoic acid to 200.0 mL of ethanoic acid.
 - Increase the pressure.
20. The substances pentane, propan-1-ol and propanone have the following structural formulae

pentane	<pre> H H H H H H — C — C — C — C — C — H H H H H H </pre>
propan-1-ol	<pre> H H H H H — C — C — C — O — H H H H •• </pre>
propanone	<pre> •• O H C H / \ / \ H C C H \ / \ / H H H H </pre>

Which of the following lists pentane, propan-1-ol and propanone in order of decreasing solubility in water?

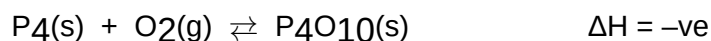
- pentane > propanone > propan-1-ol
 - propanone > pentane > propan-1-ol
 - propan-1-ol > pentane > propanone
 - propan-1-ol > propanone > pentane
21. A catalyst
- lowers the activation energy of a given reaction.
 - speeds up a reaction but does not take part in the reaction.
 - creates a new pathway for the reaction.
 - lowers the ΔH of the reaction making it easier to achieve.

22. Which is the correct equilibrium constant expression for the following equation?



- A. $\frac{[\text{Fe}_3\text{O}_4][\text{H}_2]}{[\text{Fe}][\text{H}_2\text{O}]}$
- B. $\frac{[\text{Fe}_3\text{O}_4][\text{H}_2]^4}{[\text{Fe}]^3[\text{H}_2\text{O}]}$
- C. $\frac{[\text{Fe}_3\text{O}_4] + 4[\text{H}_2]}{3[\text{Fe}] + 4[\text{H}_2\text{O}]}$
- D. $\frac{[\text{H}_2]^4}{[\text{H}_2\text{O}]^4}$

23. Consider the equilibrium established in the formation of phosphorous pentoxide:



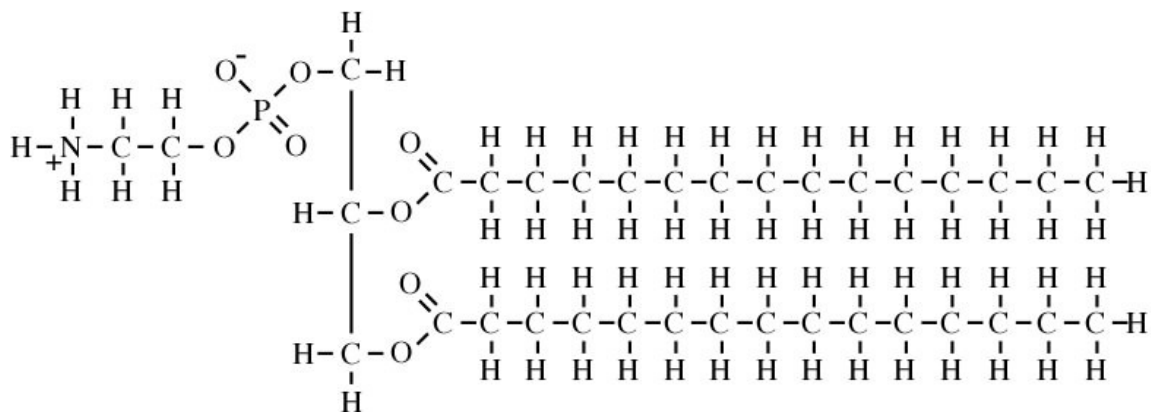
Which of the following changes would lead to a new equilibrium with a change in the concentration of O₂?

- A. Addition of P₄(s)
- B. Decreasing the surface area of P₄O₁₀(s)
- C. Addition of O₂(g) at constant volume.
- D. Decreasing the temperature at constant volume.
24. Which of the following correctly identifies the trends in atomic radii, first ionisation energy and electronegativity as you go across period 3 from Na to Cl?

	<i>Atomic radii</i>	<i>First ionisation energy</i>	<i>Electronegativity</i>
A.	decreases	increases	increases
B.	increases	decreases	increases
C.	decreases	increases	decreases
D.	increases	decreases	decreases

Question 25 refers to the following information:

Lecithin is a phospholipid found in egg yolks. It is used in the making of mayonnaise because it helps to form a stable oil/water suspension (a homogeneous mixture). It is interesting in that it is a bipolar molecule with a negatively charged oxygen atom and positively charged nitrogen atom found within the overall neutral molecule. An organic chemist wishing to show its structure might show it as in the diagram below:



25. Given that oil contains non-polar molecules, what part(s) of the structure of lecithin enable it to form the stable oil/water suspension?
- A. The bottom part of the molecule bonds with water droplets and the long hydrocarbon top parts bond with oil.
 - B. The charged parts of the molecule and the oxygen atoms throughout the molecule bond with water and the carbon/hydrogen parts of it bond with the oil.
 - C. The positive nitrogen atom bonds with water and the negative oxygen atom bonds with the oil.
 - D. The positive nitrogen atoms bond with oil and the negative oxygen atom bonds with water.

End of Section One

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

This section has **twelve (12)** questions. Answer **all** questions. Write your answers in the space provided.

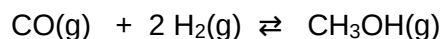
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Suggested working time: 60 minutes

Question 26**(10 marks)**

Consider the following system:



- (a) At 25 °C, $K = 2.34 \times 10^{-1}$. At 58 °C, $K = 4.56 \times 10^{-2}$.

(4 marks)

Is the forward reaction exothermic or endothermic? _____

Explain your answer:

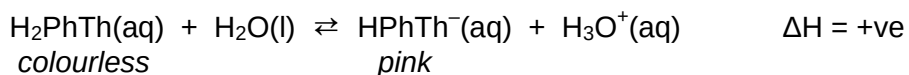
- (b) Predict whether the following changes will increase, decrease or have no effect on both the forward rate and the equilibrium yield. **(6 marks)**

<i>Change</i>	<i>Effect on rate</i>	<i>Effect on yield</i>
Increasing the pressure of the system		
Adding a catalyst		
Decreasing the temperature		

Question 27**(8 marks)**

Phenolphthalein is a diprotic acid molecule (H_2PhTh) and has two different equilibrium situations which are sensitive to concentrations of $\text{OH}^-(\text{aq})$. In the pH range less than or equal to 8.3 the molecular form is in high concentration. There is no evidence of the first ionisation step which would form $\text{H}_3\text{O}^+(\text{aq})$ and the pink coloured ion, $\text{HPhTh}^-(\text{aq})$.

If the phenolphthalein molecule is written as H_2PhTh , then the equilibrium equation for the first ionisation of phenolphthalein could be written as:



- (a) From the information given above, is the K value for the equation as written going to be high or low? Explain your answer.

(2 marks)

- (b) The following changes are imposed on a particular solution of phenolphthalein at equilibrium, which has a pale pink colour. Each change is made to a separate test tube and equilibrium is re-established.

Complete the table below, indicating the effect on the concentration of $\text{HPhTh}^-(\text{aq})$ and the value of K. Use terms 'increase', 'decrease' or 'no change'.

Also describe what you would observe as equilibrium is re-established in the system.

(6 marks)

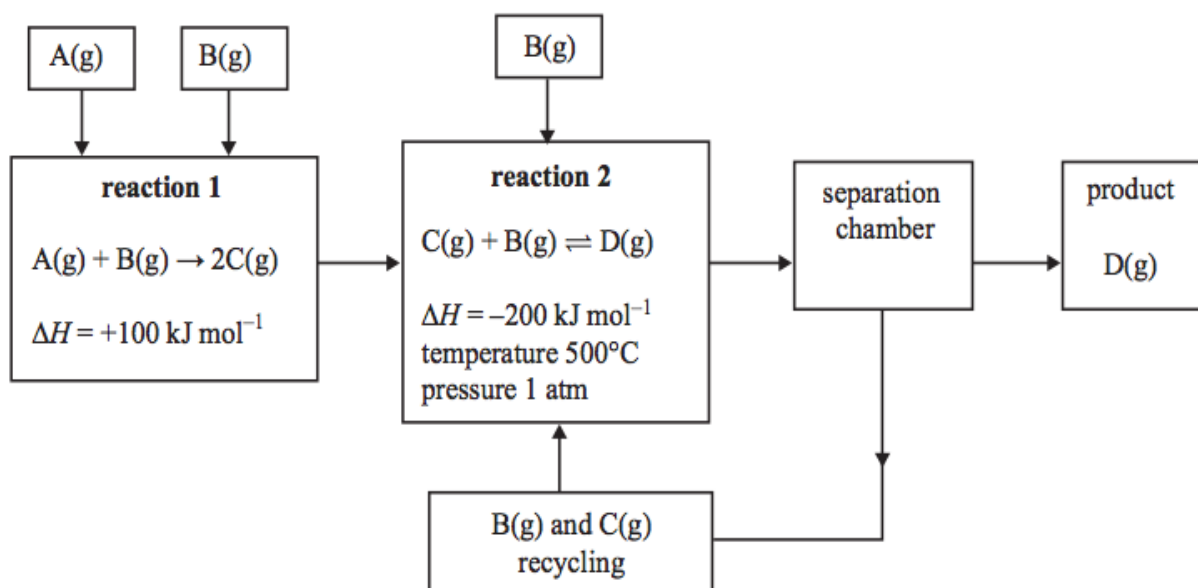
<i>Imposed change</i>	<i>Effect on $[\text{HPhTh}^-]$</i>	<i>Effect on K</i>	<i>Observation</i>
$\text{HCl}(\text{g})$ is bubbled through the solution			
The solution is heated			

Question 28**(10 marks)**

A particular industrial process involves the steps shown on the diagram below.

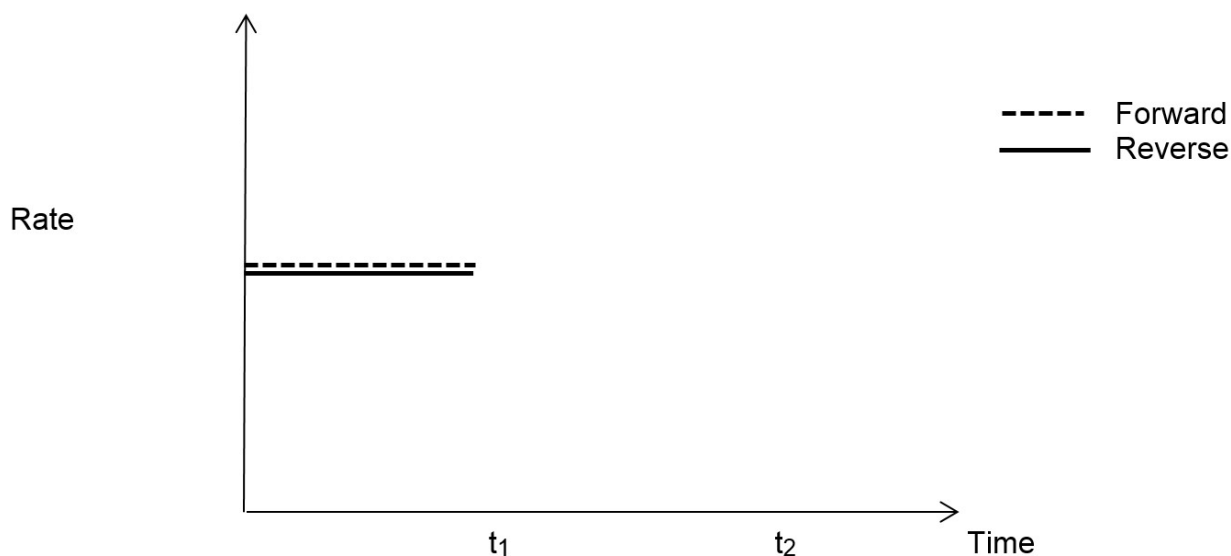
Reaction 1 proceeds to completion but reaction 2 reaches equilibrium and has a high activation energy.

The product of the industrial process, **D**, passes through a membrane in the separation chamber which is impermeable (resistant) to **B** and **C**.



Note: 1 atm = 101.3 kPa

- (a) **D** is removed from the system in the separation chamber at t_1 .
- (i) Sketch graphs on the axes below showing how this affect the rates of the forward and reverse reactions. Continue your graph until equilibrium has been re-established at t_2 . (3 marks)



- (ii) Explain the changes in rates of the forward and reverse reactions.

(4 marks)

- (b) In practice the industrial process gives a poor yield of product **D**. As the equilibrium mixture of reaction 2 moves into the separation chamber, what changes would you make to the conditions to increase the yield of **D**?

(No explanations are required)

(3 marks)

Question 29**(4 marks)**

Write the equation for the reaction that occurs in each of the following procedures. If no reaction occurs, write 'no reaction'. 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 $\text{Ag}^+(\text{aq})$], molecules [for example $\text{NH}_3(\text{g})$, $\text{NH}_3(\text{aq})$, $\text{CH}_3\text{COOH}(\text{l})$] or solids [for example $\text{BaSO}_4(\text{s})$, $\text{Cu}(\text{s})$, $\text{Na}_2\text{CO}_3(\text{s})$].

- (a) Sodium hydrogencarbonate solution is mixed with hydrochloric acid solution. (2 marks)

Equation: _____

- (b) Barium nitrate solution is mixed with sulfuric acid solution. (2 marks)

Equation: _____

Question 30**(6 marks)**

Write observations for any reactions that occur in the following procedures (a) and (b).

In each case describe in full what you would observe, including any:

- colours;
- odours;
- precipitates (give the colour); and
- gases evolved (give the colour or describe as colourless).

If no change is observed, then you should state this.

- (a) Excess hydrochloric acid is added to copper (II) carbonate solid. (2 marks)

Observation: _____

- (b) Excess iron (II) nitrate solution is mixed with sodium hydroxide solution. (2 marks)

Observation: _____

- (c) Write full observations for this reaction: (2 marks)



Observation: _____

Question 31**(5 marks)**

What is the pH of a mixture resulting from the addition of 500 mL of 0.10 mol L^{-1} NaOH and 750 mL of 0.050 mol L^{-1} HCl?

Question 32**(6 marks)**

For each species listed in the table below, draw Lewis structures, representing all valence shell electron pairs either as : or as — **and** state or draw the shape of the molecule or ion.

<i>Molecule or ion</i>	<i>Lewis structure</i>	<i>Shape</i>
H ₂ CO		
SO ₃ ²⁻		
CS ₂		

Question 33**(3 marks)**

The hydrogen phosphate ion, HPO₄²⁻(aq), is an unusual ion in that it can stabilise solutions by reacting with both small acid changes and small alkaline changes and help keep the pH at a near neutral position.

- (a) What is the term used to describe this action of the hydrogen phosphate ion? (1 mark)

- (b) Write equations showing how this ion responds to a small addition of: (2 marks)

(i) dilute hydrochloric acid _____

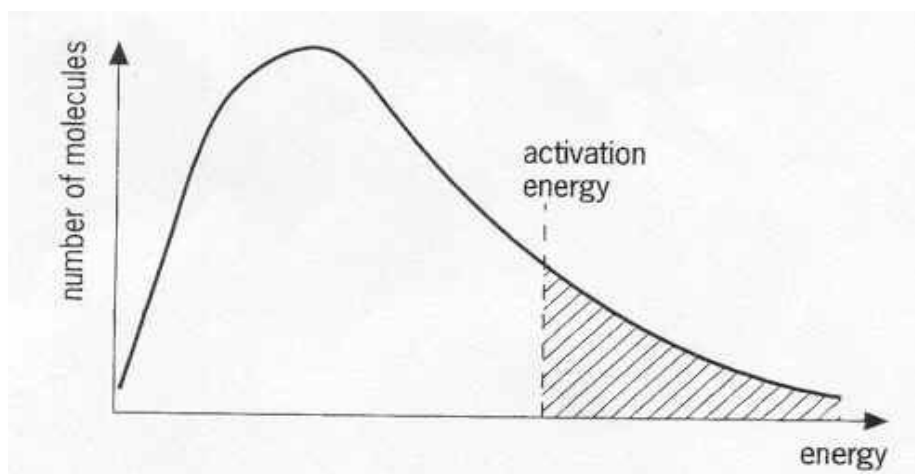
(ii) dilute potassium hydroxide _____

Question 34

(5 marks)

The diagram below shows the energy distribution curve for a gaseous reaction at 25 °C. The activation energy for the uncatalysed reaction is also indicated.

- (a) Redraw the distribution curve for a temperature of 68 °C. (1 mark)
- (b) Show on the diagram the activation energy for the catalysed reaction. (1 mark)



- (c) Explain, using the above diagram, how the rate of reaction is affected with increased temperature and addition of a catalyst. (3 marks)

[illegible]

Question 35**(4 marks)**

Chlorine forms two compounds, sodium chloride and carbon tetrachloride. Some of their properties are:

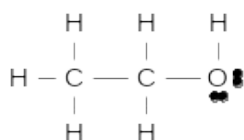
- sodium chloride melts at 801 °C, boils at 1465 °C and is a good conductor as a liquid.
- carbon tetrachloride melts at -23 °C, boils at 77 °C and is a very poor conductor as a liquid.

- (a) Explain these differences in the melting and boiling points in terms of their chemical bonding. (2 marks)

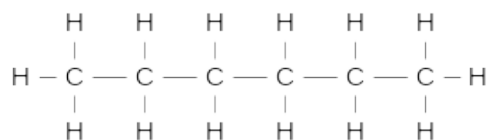
- (b) Explain the differences in their electrical conductivity in terms of their chemical bonding. (2 marks)

Question 36**(3 marks)**

It was found that glue stuck on a desk was removed using ethanol but not hexane. By considering the structures of these molecules offer an explanation as to why the glue was soluble in one solvent but not the other.



Ethanol



Hexane

Question 37**(6 marks)**

The following salt solutions were tested with litmus indicator. Litmus is a solution that becomes a red colour in solutions below pH 7 and turns blue when in solutions above pH 7. Complete the table by indicating the colour change, if any, and write equations to support your conclusion.

<i>Solution</i>	<i>Observation</i>		<i>Equation</i>
	<i>with red litmus</i>	<i>with blue litmus</i>	
NaCH_3COO			
NH_4NO_3			

End of Section Two

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

This section contains **six (6)** questions. You must answer **all** questions. Write your answers in the spaces provided.

Where questions require an explanation and/or description, marks are awarded for the relevant chemical content and also for coherence and clarity of expression. Lists or dot points are unlikely to gain full marks.

Final answers to calculations should be expressed to three (3) significant figures.

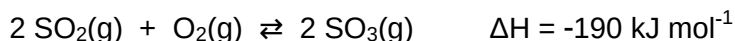
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Suggested working time: 70 minutes.

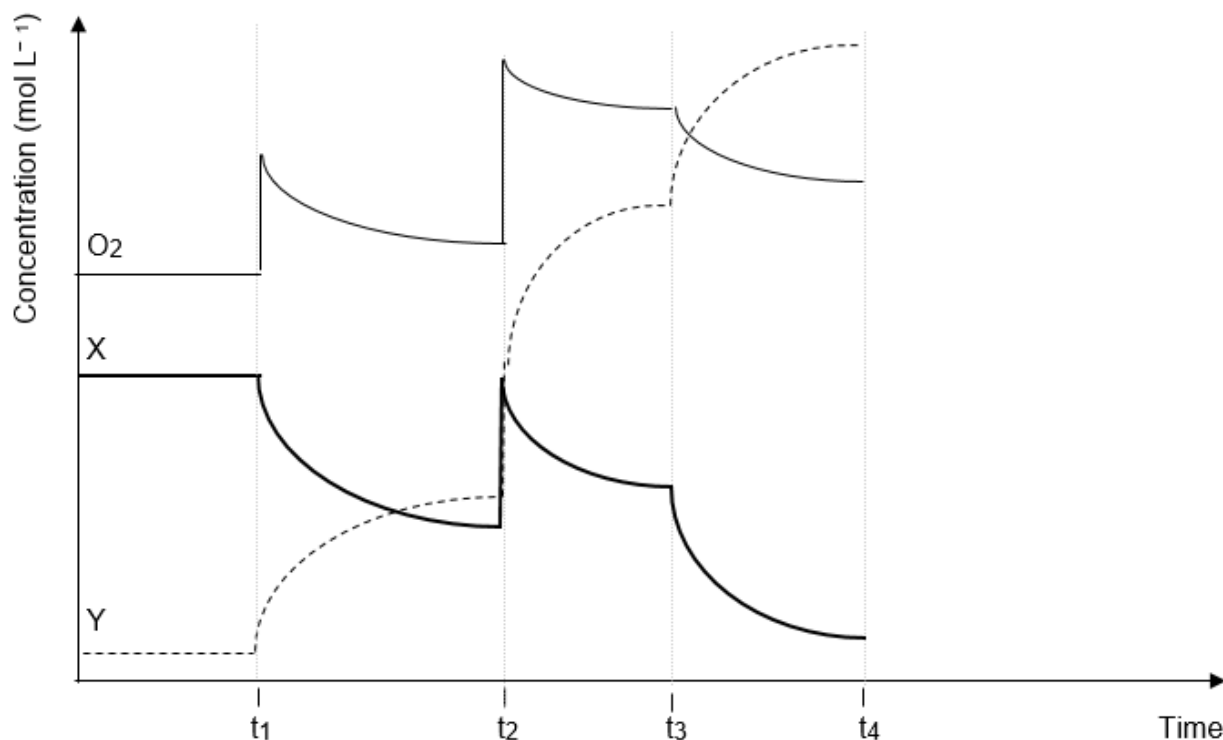
Question 38**(22 marks)**

The second stage in the manufacture of sulfuric acid via the Contact Process involves the oxidation of sulfur dioxide into sulfur trioxide.



The above reaction is at equilibrium and some changes were made to the system. The graph below represents the changes made at t_1 , t_2 , and t_3 .

(The system re-establishes equilibrium before each new change is made)



- (a) (i) Based on the change that took place at t_1 it follows that:

X = _____ and Y = _____ (1 mark)

- (ii) State what change is likely to have occurred at: (3 marks)

t_1 _____

t_2 _____

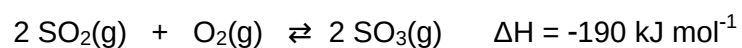
t_3 _____

- (iii) At t_4 , a catalyst, vanadium pentoxide (V_2O_5), is added to the system. Continue the graphs to represent the changes in concentration of the three gases when a catalyst is added. (1 mark)

Question 38 continued

- (b) In the Contact Process, it is important to maximise both the yield of SO_3 and the rate of reaction. Use your knowledge of equilibrium and rates to predict and explain the optimum conditions of temperature and pressure for production of SO_3 .

The equation for the production of SO_3 is repeated below:



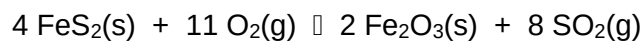
(7 marks)

This image shows a blank sheet of white paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

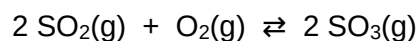
The full manufacture of sulfuric acid can be summarised in four main steps.

Step 1 Mining of “pyrite ore”, which contains, by mass, 73.00% FeS_2 .

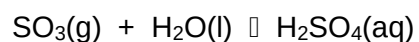
Step 2 Roasting of the ore to convert the sulfur into sulfur dioxide



Step 3 The oxidation of sulfur dioxide, which is only 68.00% efficient.



Step 4 Reaction of sulfur trioxide with water to form sulfuric acid



(c) Calculate the mass of sulfuric acid that can be produced from 1.000 tonne (1000 kg) of “pyrite ore”. (You may assume that all other reactions are 100% efficient) (7 marks)

[illegible]

Question 38 continued

- (d) The commercial concentrated sulfuric acid produced by this process has a concentration of 18.00 mol L^{-1} . Using your answer to (c), what volume of this acid can be formed? Give your answer to four (4) significant figures. (3 marks)

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Question 39**(13 marks)**

This question concerns the three elements sodium, potassium and magnesium.

- (a) Write equations to represent the first and seventh ionisation energies of sodium. (2 marks)

1st I.E. _____

7th I.E. _____

- (b) Sketch a graph to show the trend in **all** the ionisation energies of sodium. (3 marks)



- (c) Explain the shape of the above graph. (3 marks)

- (d) Which will have the higher first ionisation energy, sodium or potassium? Explain. (2 marks)

- (e) Arrange the three elements (Na, K, Mg) in order of increasing electronegativity and explain your choice. (3 marks)

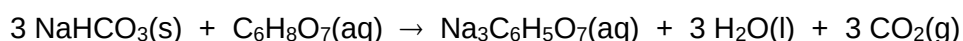
Order: *lowest* _____ *highest*

Explanation:

Question 40**(9 marks)**

Alka-Seltzer is a water soluble medication that can treat acid indigestion in two ways; by neutralising stomach acid using sodium hydrogencarbonate and treating the associated pain by using aspirin ($\text{C}_9\text{H}_8\text{O}_4$). When Alka-Seltzer was developed in the early part of the twentieth century, it was found that the solubility of the active ingredients were improved if a reaction that gives off a gas took place when the tablet was added to water. Therefore solid citric acid ($\text{C}_6\text{H}_8\text{O}_7$) was added to the mixture to react with some of the sodium hydrogencarbonate.

The reaction causing the effervescence is



The normal composition of one Alka-Seltzer tablet is

Sodium hydrogencarbonate 1700 mg

Aspirin 325 mg

Citric acid 300 mg

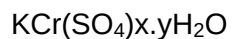
- (a) One tablet of Alka-Seltzer is completely dissolved in 270.0 mL of water, and all the bubbling has stopped. Calculate the final concentration in mol L^{-1} of

- (i) sodium hydrogen carbonate (2 marks)

- (ii) aspirin (2 marks)

Question 41**(13 marks)**

An unusual hydrated sulfate compound containing both potassium and chromium (III) has the general formula



where both 'x' and 'y' are both integers.

If 36.5 g of the pure, hydrated compound is treated with excess sodium carbonate solution it is found that 10.38 g of highly insoluble chromium(III) carbonate is precipitated.

- (a) Determine the number of mole of chromium in the hydrated compound.

(2 marks)

- (b) Determine the molar mass of the compound.

(2 marks)

A further 4.70 g sample of the compound is heated strongly to drive off the water of crystallisation. A constant mass of 2.665 g of anhydrous powder remains after several subsequent heatings.

(c) Calculate the values of 'x' and 'y' in the formula of the compound.

(9 marks)

Question 42**(15 marks)**

An unknown amino acid, X, containing the elements C, H, N and O, was subjected to analysis in order to determine its formula.

1st experiment 2.07 g of X was completely burned in excess oxygen and 3.07 g of carbon dioxide and 1.45 g of water were formed.

2nd experiment 1.68 g of X was reacted so as to convert all the nitrogen into nitrogen gas (N₂). It was found that the gas formed occupied 211 mL, measured at STP.

3rd experiment 1.39 g of X was vapourised at 200 °C and 105 kPa and was found to occupy a volume of 584 mL.

(a) Calculate the empirical formula of X.

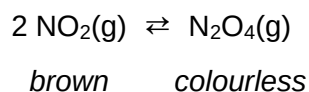
(12 marks)

(b) Calculate the molecular formula of X.

(3 marks)

Question 43**(8 marks)**

A student investigated the equilibrium system involving brown nitrogen dioxide gas (NO_2) and colourless dinitrogen tetroxide as (N_2O_4).



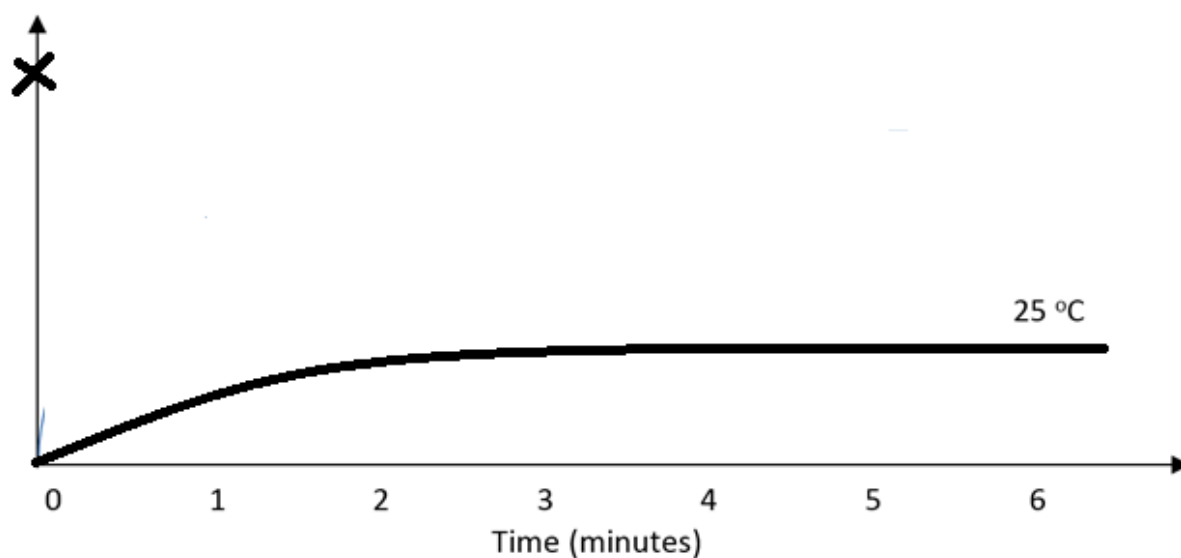
Nitrogen dioxide gas was placed into a reaction chamber as shown and allowed to reach equilibrium



The colour of the mixture was compared under different reaction conditions.

<i>Temperature (°C)</i>	<i>Pressure (kPa)</i>	<i>Colour</i>
0	100	light brown
25	100	brown
100	100	dark brown

The graph represents the change in concentration of N_2O_4 as the reaction proceeds to equilibrium at 25 °C. The 'X' on the concentration axis represents the initial concentration of $\text{NO}_2(\text{g})$.



- (a) Which reaction was favoured as the temperature increased? Explain your choice. (2 marks)

- (b) Is the forward reaction endothermic or exothermic? Explain your choice. (2 marks)

- (c) On the graph on the previous page, sketch a curve that represents the concentration of $\text{NO}_2(\text{g})$ over the six minute period. (2 marks)

- (d) At what temperature were reactions in the equilibrium mixture occurring most quickly? Explain why the rate of reaction was highest at this temperature. (2 marks)

End of Examination

[illegible]

[illegible]