Mid-Year Examination, 2013

Question/Answer Booklet

CHEMISTRY

Year 12

Place your student identification label in this box

Student Number: In figures ☐☐ - ☐☐☐ - ☐☐☐

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 approved for use in the WACE examinations

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	ALL	50	50	25
Section Two: Short answer	11	ALL	60	70	35
Section Three: Extended answer	5	ALL	70	80	40
				Total	100

Instructions to candidates

1. 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 and shade your new answer. Do not erase or use correction fluid/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.

2. When calculating numerical answers, show your working or reasoning clearly unless instructed otherwise. Final answers to calculations should be expressed to three (3) significant figures.

3. 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.

4. 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.

5. The Chemistry Data Sheet will be collected with your Question/Answer Booklet

Section One: Multiple Choice 25 marks (25% of paper)

This section contains 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 and shade your new answer. Do not erase or use correction fluid/tape. 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: 50 minutes

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1. A catalyst can decrease the time taken for a chemical system to reach equilibrium. This is best explained by the catalyst:

   A. increasing the energy of the collisions so that a greater proportion result in a chemical reaction.

   B. increasing the enthalpy of the reactants, thereby increasing the frequency of successful collisions.

   C. providing an alternative transition state for the reaction with lower energy.

   D. decreasing the rate of the reverse reaction so that the product is produced more quickly.

2. $PC\ell_5$ is prepared from the reaction between $PC\ell_3$ and $C\ell_2$, resulting in the establishment of the following equilibrium:

$$PC\ell_3(g) + C\ell_2(g) \rightleftharpoons PC\ell_5(g)$$

   Four different flasks, labelled A, B, C and D, at the same temperature, each contain a gaseous mixture of $PC\ell_5$, $PC\ell_3$ and $C\ell_2$. The concentration, in mol L^{-1}, of these components in each of the flasks is shown below.

   In three of the four flasks, the mixture of gases is at equilibrium. In which one is the mixture of gases not at equilibrium?

Flask	$[PC\ell_3(g)]$	$[C\ell_2(g)]$	$[PC\ell_5(g)]$
A.	0.20	0.30	0.15
B.	0.15	0.15	0.20
C.	0.10	0.40	0.10
D.	0.80	0.15	0.30

3. Carbon disulfide, CS_2, is used as a solvent for many industrial processes. It can be prepared by heating carbon in the presence of $H_2S(g)$ at high temperatures.

$$C(s) + 2\,H_2S(g) \rightleftharpoons CS_2(g) + 2\,H_2(g) \qquad \Delta H = +84.0\ kJ\ mol^{-1}$$

Which of the following would result in an increase in the yield of carbon disulfide?

I Adding more carbon

II Decreasing the volume of the system

III Removal of hydrogen gas from the system

IV Increasing the temperature of the system

A. I and IV only

B. III and IV only

C. I, II and IV only

D. I, II, III and IV

4. When solutions of potassium thiocyanate (KSCN) and iron(III) chloride are mixed, the following equilibrium is established:

$$Fe^{3+}(aq) + SCN^{-}(aq) \rightleftharpoons FeSCN^{2+}(aq) \qquad \Delta H = -ve$$

brown *red*

The intensity of the red colour of the solution could be increased by the addition of:

A. Ag^{+} ions, which form AgSCN(s).

B. $Sn^{2+}(aq)$, which converts $Fe^{3+}(aq)$ to $Fe^{2+}(aq)$.

C. a small volume of water.

D. a small quantity of concentrated $Fe(NO_3)_3$ solution.

5. The anaesthetic, nitrous oxide (N_2O) decomposes to form an equilibrium mixture of N_2O, N_2 and O_2 according to the following equation:

$$2\,N_2O(g) \rightleftharpoons 2\,N_2(g) + O_2(g)$$

At 25°C, $K = 7.3 \times 10^{37}$ and at 40°C, $K = 2.7 \times 10^{36}$

What valid conclusion can be made from this?

A. The equilibrium concentrations of N_2 and O_2 are equal at 25°C.

B. The equilibrium concentration of N_2O is higher at 25°C than at 40°C.

C. N_2O is less stable at the higher temperature.

D. The forward reaction is exothermic.

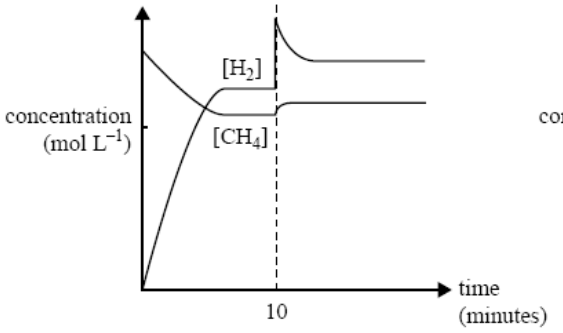
6. The following gaseous equilibrium is established at high temperatures in the presence of a finely divided nickel catalyst.

$$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3\,H_2(g) \qquad \Delta H = +206 \text{ kJ mol}^{-1}$$

Equal amounts of $CH_4(g)$ and $H_2O(g)$ are added to a reaction vessel and allowed to react and reach equilibrium. At 10 minutes, some $H_2(g)$ is added to the mixture and equilibrium is re-established.

Which one of the following graphs best represents the changes in $[CH_4]$ and $[H_2]$ in the reaction mixture during this time?

A.



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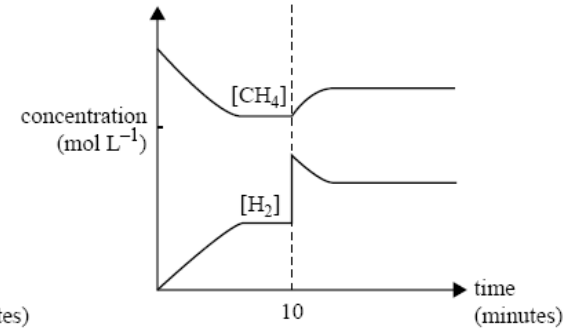
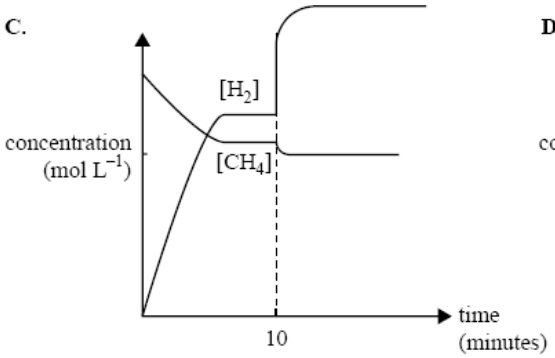
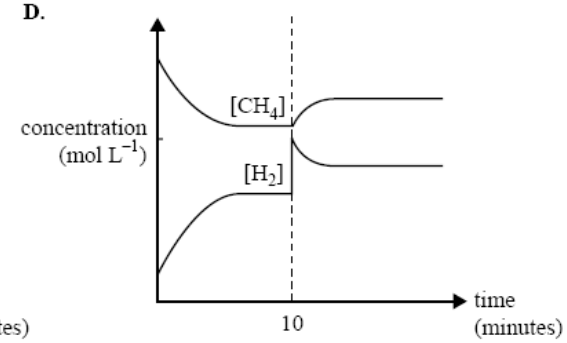


C.



D.



7. Consider the equilibrium established in the formation of tetraphosphorous decoxide:

$$P_4(s) + 5\,O_2(g) \rightleftharpoons P_4O_{10}(s) \qquad \Delta H = -ve$$

Which of the following changes would lead to a new equilibrium with a different final concentration of O_2?

A. Addition of $P_4(s)$

B. Decreasing the surface area of $P_4O_{10}(s)$

C. Addition of $O_2(g)$

D. Decreasing the temperature.

8. Ethanol can be manufactured by the reaction between ethene and water. This is represented by the equation:

$$C_2H_4(g) + H_2O(g) \rightleftharpoons C_2H_5OH(g) \qquad \Delta H = -46 \text{ kJ mol}^{-1}$$

Which conditions would produce the fastest rate for the forward reaction?

A. Low pressure and low temperature.

B. High pressure and low temperature

C. Low pressure and high temperature

D. High pressure and high temperature

9. 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?

	Atomic radii	*First Ionisation Energy*	*Electronegativity*
A.	Increases	Decreases	Increases
B.	Decreases	Increases	Increases
C.	Decreases	Increases	Decreases
D.	Increases	Decreases	Decreases

10. Consider the following successive ionisation energies of elements X and Y.

Element X

Ionisation	1st	2nd	3rd	4th	5th	6th	7th	8th
Ionisation Energy (kJ mol^{-1})	1,310	3,390	5,320	7,450	11,000	13,300	71,000	91,600

Element Y

Ionisation	1st	2nd	3rd	4th	5th	6th	7th	8th
Ionisation Energy (kJ mol^{-1})	577	1,820	2,740	11,600	14,800	18,400	23,400	27,500

The compound formed between X and Y would most likely be:

A. a covalent compound of formula YX_3.

B. an ionic compound of formula Y_2X_3.

C. a covalent compound of formula Y_2X_3.

D. an ionic compound of formula Y_3X_2.

11. A molecule formed by atoms with atomic numbers of 7 and 9 will be:

A. pyramidal and polar

B. pyramidal and non-polar

C. triangular planar and polar

D. triangular planar and non-polar

12. Molecules of $COC\ell_2$ and SO_3 are both triangular planar. Which one of the following statements is true?

A. Both $COC\ell_2$ and SO_3 are non-polar.

B. Both $COC\ell_2$ and SO_3 are polar.

C. $COC\ell_2$ is non-polar whereas SO_3 is polar.

D. $COC\ell_2$ is polar whereas SO_3 is non-polar.

13. Consider the table below showing some data for the halogens.

Halogen	Atomic number	Molecular mass	Melting point (^oC)
F_2	9	38	–220
$C\ell_2$	17	71	–101
Br_2	35	160	–7
I_2	53	254	114

Which one of the following statements best explains why the melting points of the halogens increase with increasing atomic number?

A. The number of electrons increases, resulting in the formation of stronger covalent bonds.

B. The increased number of electrons causes the molecules to be more polar.

C. An increased number of protons and electrons lead to stronger dispersion forces.

D. As the molecular mass increases so does the strength of bonds.

14. Consider the alcohols, butan-1-ol and hexan-1-ol. Compared to butan-1-ol, hexan-1-ol would have:

A. a higher boiling point and greater solubility in water.

B. a higher boiling point and lower solubility in water.

C. a lower boiling point and greater solubility in water.

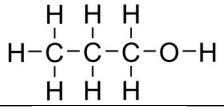
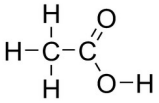
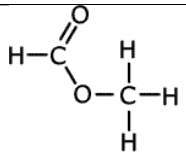
D. a lower boiling point and lower solubility in water.

15. Which of the following molecules can form hydrogen bonds with water molecules?

I. methanol
II. ethanal
III. methanamine
IV. hydrogen fluoride

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

16. The table shows information regarding three compounds.

Compound	*Structural formula*	*Molar mass ($g\ mol^{-1}$)*	*Boiling point (°C)*
X		60.1	97
Y		60.1	118
Z		60.1	?

What is the best estimate for the boiling point of compound **Z**?

A. 31°C
B. 101°C
C. 114°C
D. 156°C

17. Which of the following has a different empirical formula to the others?

A. Methylethanoate
B. Ethylethanoate
C. Butanoic acid
D. Ethanal

18. How many isomers are there for $C_3H_6BrC\ell$?

A. 3

B. 4

C. 5

D. 6

19. Which one of the following pairs of organic compounds are not isomers?

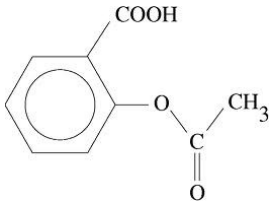
A. Pentane and dimethylpropane

B. Methylpropane and cyclobutane

C. Ethylhexane and 2,2,4-trimethylpentane

D. Cyclohexane and 2-methylpent-1-ene

20. Aspirin contains the following substance:



Which of the following functional groups does aspirin contain?

I. aldehyde

II. ketone

III. carboxylic acid

IV. ester

A. I and II

B. II and III

C. III and IV

D. I, II, III and IV

21. Which of the following could be oxidised to a ketone using acidified potassium dichromate solution?

A. Cyclohexanol

B. Methyl-2-propanol

C. Methanol

D. Ethanol

22. Which of the following pairs of compounds would form 1-propylethanoate when warmed with sulfuric acid?

A. CH_3CH_2COOH and CH_3CH_2OH

B. CH_3CH_2OH and $CH_3CH_2CH_2OH$

C. CH_3COOH and $CH_3CH_2CH_2OH$

D. CH_3OH and CH_3COOH

23. Which of the following substances can exhibit geometrical isomerism?

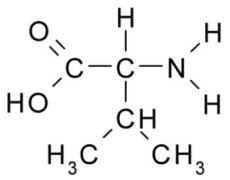
A. 1-fluoro-1-bromoethene

B. Propene

C. 2-methylbut-2-ene

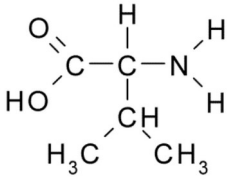
D. 3-methylpent-2-ene

24. A molecule of valine has the following structure:



Which of the following best represents the structure of valine when dissolved in a hydrochloric acid solution with a pH of 3?

A.



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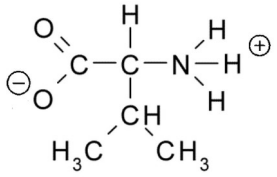
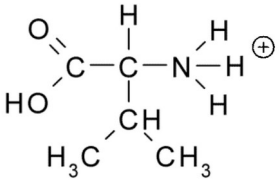
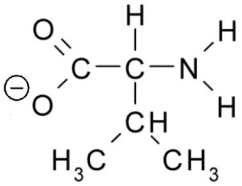


C.



D.



25. A particular polymer can be represented by the formula:

$$-(-OC\text{-}CH_2\text{-}CO\text{-}NH\text{-}CH_2CH(CH_3)\text{-}NH-)-_n$$

Which of the following pairs of monomers would be required to prepare this polymer?

A. $HOCH_2CH_2CH_2OH$ and $H_2NCH_2CH(CH_3)NH_2$

B. $HOOCCH_2COOH$ and $H_2NCH_2CH(CH_3)NH_2$

C. $HOOCCH_2CONH_2$ and $CH_3CH(CH_3)NHCOOH$

D. $HOOCCH_2COOH$ and $H_2NCHC(CH_3)NH_2$

End of Section One

Section Two: Short Answer **70 marks (35% of paper)**

This section has **11** questions. Answer **all** questions. Write your answers in the spaces provided.

Spare pages are included at the end of this booklet. They can be used for planning your responses and/or 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.

Suggested working time: 60 minutes

Question 26 **(6 marks)**

(a) Describe one chemical test that may be used to distinguish between the two colourless liquids methanol and methanal. State the observations with each chemical.

Test: _____

Observation with methanol: _____

_____

Observation with methanal: _____

_____

(3 marks)

(b) A soap has the formula $CH_3(CH_2)_{16}COONa$. Draw the structure of the triester (triglyceride) that this soap was prepared from.

(2 marks)

What must be added to this triester to produce soap? _____

(1 mark)

Question 27 **(4 marks)**

Iron(III) chloride dissolves in water to form a pale brown solution. Over time, a brown precipitate of $Fe(OH)_3$ is formed, establishing the following equilibrium:

$$Fe^{3+}(aq) + 3\,H_2O(l) \rightleftharpoons Fe(OH)_3(s) + 3\,H^+(aq)$$

(a) Give one observation when some $Fe(OH)_3(s)$ is added to above equilibrium.

(1 mark)

(b) What chemical could be added to a solution of iron(III) chloride to prevent the precipitation of iron(III) hydroxide? Give a reason why this would reduce precipitation.

Chemical recommended

(1 mark)

Reason

(2 marks)

Question 28 **(4 marks)**

For each species listed in the table below, draw the structural formula, representing all valence shell electron pairs as : or as –

Nitrogen trichloride, $NC\ell_3$	Hydrogencarbonate ion, HCO_3^-

Question 29 **(7 marks)**

(a) The first ionisation energies of five **consecutive** elements of the Periodic Table are shown below.

Element	First Ionisation Energy (kJ mol^{-1})
V	1310
W	1680
X	2080
Y	495
Z	733

Which element in the above table would be a halogen? _____

(1 mark)

(b) Place the following in order of increasing 1st ionisation energy Mg, Na, Cs, Cℓ, P

_____

(1 mark)

Give an explanation for your answer.

_____

_____

_____

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(5 marks)

Question 30 **(6 marks)**

(a) Write ionic chemical equations for the following:

(i) The reaction between a green solid and a colourless solution that produces a colourless gas and a blue solution.

(2 marks)

(ii) Excess cobalt(II) nitrate solution is added to sodium phosphate solution.

(2 marks)

(b) Give complete observations for the reaction that occurred in (ii) above.

(2 marks)

Question 31 **(6 marks)**

A sweet smelling liquid, **A**, has a molecular formula $C_4H_8O_2$. **A** was prepared from reacting liquids **B** and **C** in the presence of concentrated H_2SO_4.

Liquid **C**, when oxidised by MnO_4^-/H^+, produced a ketone.

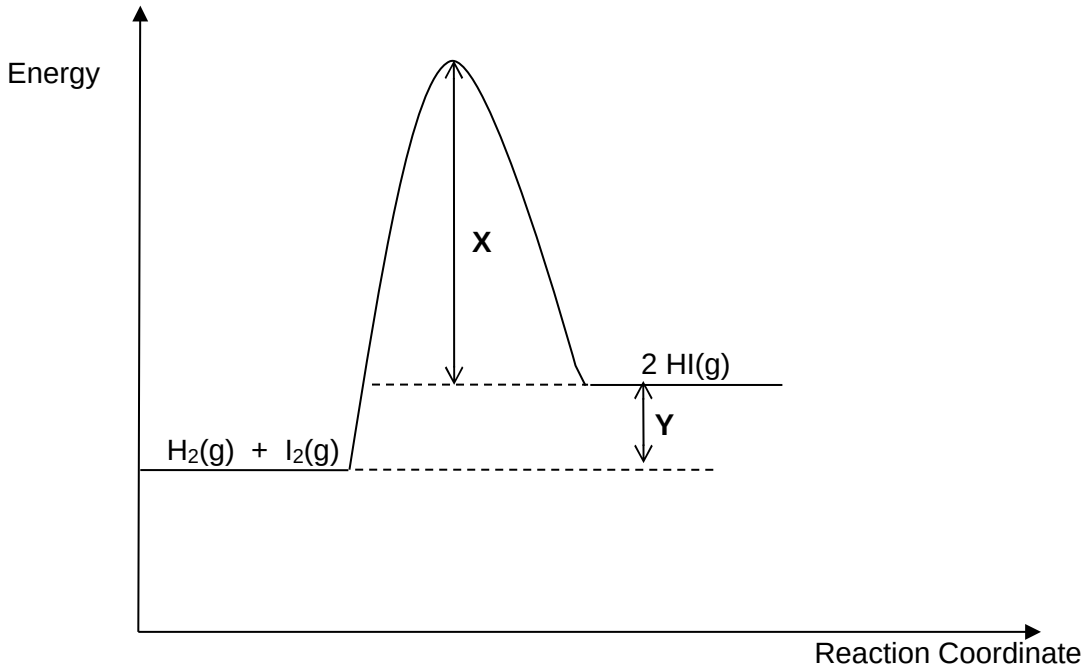
Name of Liquid **A**	Structure of Liquid **A**
Name of Liquid **B**	Structure of Liquid **B**
Name of Liquid **C**	Structure of Liquid **C**

Question 32 **(6 marks)**

Shown below is the energy profile diagram for the reversible reaction:

$$H_2(g) + I_2(g) \rightleftharpoons 2\ HI(g)$$

Answer the following questions in terms of X and Y. You may have to use > (greater than) and < (less than) signs in your responses.



(a) What is the enthalpy change [ΔH] for the forward reaction? _____

(b) What is the enthalpy change [ΔH] for the reverse reaction? _____

(c) What is the activation energy for the forward reaction? _____

(d) What is the activation energy for the reverse reaction? _____

(e) What is the ΔH for the forward reaction if a catalyst is used? _____

(f) What would be the activation energy of the pathway provided by a catalyst for the forward reaction? _____

Question 33 **(7 marks)**

Aluminium (Aℓ), magnesium (Mg), sulfur (S_8) and (P_4) are all elemental solids in period 3 of the Periodic Table.

List the melting points of these solids in *increasing* order _____

(1 mark)

Justify your answer.

(6 marks)

Question 34 **(8 marks)**

Three hydrocarbons **X**, **Y** and **Z** undergo addition reactions with HBr(g).

Hydrocarbons **X** and **Y** give a **single** product 2-bromobutane.

On addition reaction with HBr compound **Z** can produce two products, **T** and **L**.

L is also 2-bromobutane.

Complete this table:

Compound	Structure	IUPAC Name
X		
Y		
Z		
T		

Question 35 **(11 marks)**

Chlorine reacts with carbon monoxide as follows:

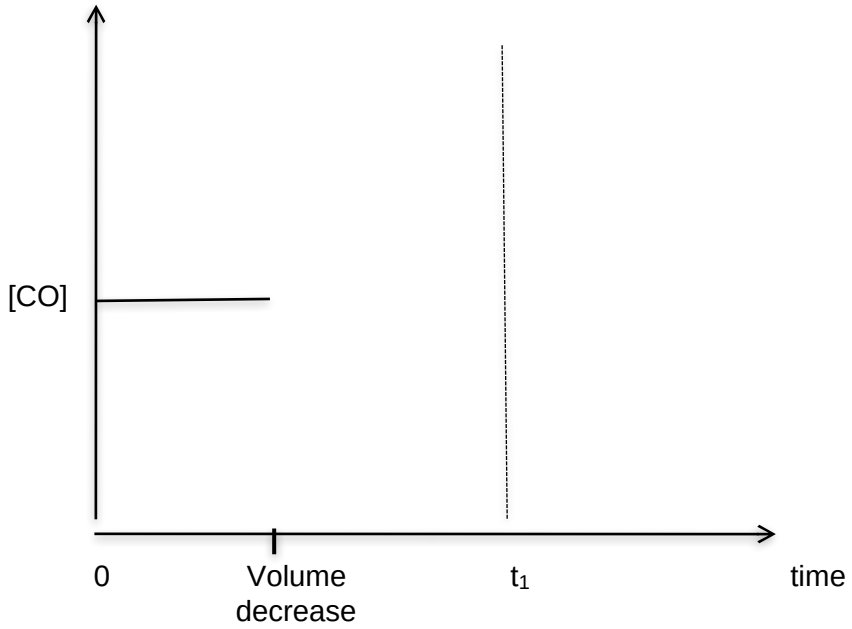
$$C\ell_2(g) + CO(g) \rightleftharpoons COC\ell_2(g) \qquad \Delta H < 0$$

(a) Consider the imposed changes described below and identify the changes which have occurred to the total pressure of the container, the concentration of CO and the mass of CO, once equilibrium has been re-established. Complete this table by writing increase, decrease or no change.

Imposed Change	Total pressure of the container	Concentration of CO	Mass of CO
(i) The volume of the container is decreased			
(ii) The temperature of the system is increased			
(iii) Ne(g) is added at constant volume			

(9 marks)

(b) Complete the sketch below for imposed change (i) until equilibrium is re-established at t_1.



(2 marks)

Question 36 **(5 marks)**

A and **B** are both amino acids.

A H_2NCH_2COOH and **B** $H_2NCH_2CH_2COOH$

(a) Which of the two amino acids above is **not** an α-amino acid? _____

(1 mark)

Justify your choice

_____

_____

_____

_____

(1 mark)

(b) The non α-amino acid identified in (a) can be redrawn as an isomer that is an α-amino acid. Draw this isomer.

(1 mark)

(c) Dipeptides are the major organic product formed when two amino acids. Draw one dipeptide formed in the reaction between **A** and **B**.

(2 marks)

End of Section Two

Section Three: Extended answer 80 marks (40% of paper)

This section contains **five** 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.

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.

Suggested working time: 70 minutes

Question 37 **(19 marks)**

2.42 g of substance **X,** containing only the elements carbon, hydrogen and oxygen was divided into two equal samples. The first sample, on complete combustion in a dry stream of oxygen, produced 3.03 g of carbon dioxide. The second sample produced 1.24 g of water under the same experimental conditions.

(a) Determine the empirical formula of substance **X**.

(6 marks)

Question 37 (continued)

(b) When vapourised, a 0.650 g sample of **X** was found to occupy 48.1 mL at a pressure of 213 kPa and temperature of 27°C. Determine the molecular formula of **X**.

(4 marks)

(c) Substance **X** is an ester. Write a balanced equation showing how the ester ethylpropanoate could be made.

(2 marks)

(d) When the ester 1-octylmethanoate is treated with concentrated acid, two substances **Y** and **Z** are made. Complete the table below giving the structural formula of **Y** and **Z**.

Structure	Solubility in water
	Miscible
	Immiscible

(2 marks)

Question 37 (continued)

(e) Give a full account of the bonding present in pure samples of ethanoic acid and hexan-1-ol and explain the difference in their solubility in water.

(5 marks)

Question 38 **(14 marks)**

0.452 g of a mixture of barium chloride and barium hydroxide was dissolved in water and made up to a volume of 50.0 mL. This solution required 14.3 mL of 0.115 mol L^{-1} hydrochloric acid for neutralisation.

(a) Determine the number of moles of barium hydroxide in the 0.452 g mixture.

(3 marks)

(b) Determine the mass of barium chloride in the 0.452 g mixture.

(2 marks)

(c) What is the concentration of barium ions in solution after neutralisation?

(5 marks)

Question 38 (continued)

(d) What volume of 0.0500 mol L^{-1} of silver nitrate solution would be required to precipitate the chloride ions from the solution after the addition of HCℓ(aq)?

(4 marks)

Question 39 **(11 marks)**

Sodium azide, NaN_3, is used in car airbags and escape chutes in aircraft and decomposes at high temperature to produce nitrogen gas. Sodium metal produced in the reaction subsequently reacts with potassium nitrate and silicon dioxide to produce harmless substances, including potassium silicate glass and sodium silicate glass. The reactions involved and their percentage efficiencies are shown below.

Reaction 1: $2\ NaN_3 \rightarrow 2\ Na + 3\ N_2(g)$ 97%

Reaction 2: $10\ Na + 2\ KNO_3 \rightarrow K_2O + 5\ Na_2O + N_2(g)$ 99%

Reaction 3: $K_2O + Na_2O + 2\ SiO_2 \rightarrow K_2O_3Si + Na_2O_3Si$ 92%
silicate glass

If 80.0 g of sodium azide are used in a typical airbag calculate the following:

(a) The number of moles of sodium produced in reaction 1.

(2 marks)

(b) The number of moles of potassium oxide produced in reaction 2.

(2 marks)

Question 39 (continued)

(c) The mass of the sodium silicate glass, Na_2O_3Si, produced in reaction 3. .

(2 marks)

(d) Calculate the volume of nitrogen gas produced at 101.3 kPa and 25°C.

(5 marks)

Question 40 **(17 marks)**

Methanal (CH_2O) is an important industrial chemical. It is made by the oxidation of methanol:

$$2\ CH_3OH(g)\ +\ O_2(g)\ \rightleftharpoons\ 2\ CH_2O(g)\ +\ 2\ H_2O(g) \qquad \Delta H = -570\ kJ\ mol^{-1}$$

(a) If the temperature of a sample of this system at equilibrium is raised what effect will this have on the value of the equilibrium constant K? Give the equilibrium expression and explain the effect of temperature change.

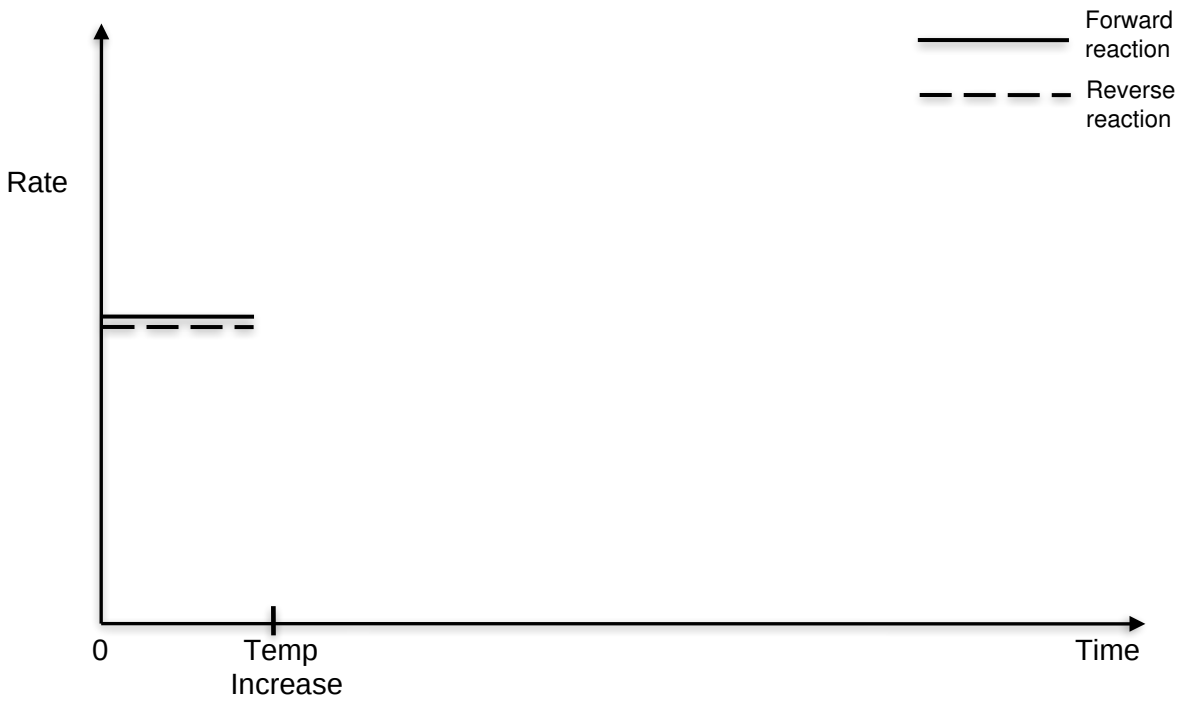
K =

(1 mark)

Explanation:

(2 marks)

(b) Complete the graph to show the changes in reaction rate associated with an increase of temperature in the sample until equilibrium is re-established.



(3 marks)

Question 40 (continued)

(c) Predict what temperature and pressure conditions (high, low or moderate) would be most favourable for producing methanal industrially and explain your prediction using the Collision Theory and Le Chatelier's Principle.

(6 marks)

Question 40 (continued)

(d) Propanal, an aldehyde, can be made commercially by reacting carbon monoxide, hydrogen gas and ethene in the presence of a catalyst. In the laboratory, propanal can be made using propan-1-ol in a different reaction to that used commercially.

(i) Give details for the reagent(s) needed for the laboratory preparation of propanal from propan-1-ol and any observations that could be expected.

Reagents: _____

_____

(1 mark)

Observation: _____

_____

_____

(1 mark)

(ii) If propan-1-ol is added in excess but all other reactants are in the correct stoichiometric ratios, both propanal and propan-1-ol will be present in the final mixture. State a suitable method to separate the two liquids and explain your choice.

Separation method: _____

_____

(1 mark)

Explanation: _____

_____

_____

_____

_____

_____

_____

(2 marks)

Question 41 **(19 marks)**

The physical properties of substances can be explained using knowledge of bonding and atomic structure.

(a) Examine the table of physical properties for a number of elements and their associated oxides.

Element	Melting Point (°C)	First Ionisation Energy (MJ mol^{-1})	Electrical conductivity (MS m^{-1})	Oxide and melting point (°C)
Sodium	98	0.49	20	Na_2O 801
Potassium	63	0.43	14	Not given
Germanium	937	0.77	1×10^{-6}	GeO_2 1150
Chlorine	-101	1.25	0	$C\ell O_2$ –59

(i) State and explain the type of bonding present in germanium.

(3 marks)

Question 41 (continued)

(ii) Explain why sodium has a higher first ionisation energy than potassium.

(2 marks)

(iii) Explain why both sodium and potassium have high electrical conductivity while germanium and chlorine have conductivities that are effectively zero.

(2 marks)

(iv) Explain why the oxides given have high melting points with the exception of chlorine.

(3 marks)

Question 41 (continued)

(b) The substances below have different boiling points. In the table, rank them in order of decreasing boiling point and explain your choice.

Substance	Molar mass (g mol^{-1})	Boiling points in order (1 = highest, 5 = lowest)
hexane	86.172	
butanoic acid	88.104	
2-methylpentane	86.172	
pentan-1-ol	88.146	
pentanal	86.130	

(3 marks)

Explanation:

End of questions (6 marks)

Additional Working Space

- Planning: If you use the spare pages for planning, indicate this clearly at the top of the page.
- Continuing an answer: If you need 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.

Additional Working Space

Additional Working Space

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