CHEMISTRY
Stage 3

Student Name: _____

Class Teacher: Mrs Templeton-Knight ☐   Mr Davey ☐

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, 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 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 1 Multiple choice	25	25	50	/50	25
Section 2 Short answer	10	10	60	/70	35
Section 3 Extended answer	8	8	70	/80	40
				/200	%

Instructions to candidates

1. The rules for the conduct of Western Australian external examinations are detailed in the *Year 12 Information Handbook 2015.* 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, 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.

3. When calculating numerical answers, show your working or reasoning clearly unless instructed otherwise.

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 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 1: Multiple Choice   (50 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, 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. Each question in this part is worth 2 marks.

Suggested working time for this section is 50 minutes.

1.   Raising the temperature of the system:

$$N_2(g) + 3 H_2(g) \rightleftharpoons 2 NH_3(g) + 45kJ$$
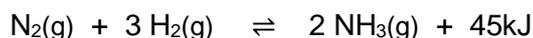
A   increases the rate of ammonia formation and has no effect on the yield of ammonia in the equilibrium mixture

B   increases the rate of ammonia formation and decreases the yield of ammonia in the equilibrium mixture

C   increases the rate of ammonia formation and increases the yield of ammonia in the equilibrium mixture

D   decreases the rate of ammonia formation and decreases the yield of ammonia in the equilibrium mixture

2.   Which of the following species has an equal number of protons and neutrons and also contains six less neutrons that a ^{39}K atom?

A ^{26}Al
B ^{28}Si
C ^{30}P
D ^{32}S

3.   Boron nitride, BN, is insoluble in water, has very poor electrical conductivity in any state and melts at 2973ºC. The most likely structure of solid boron nitride is:

A   ionic.
B   organic.
C   covalent molecular.
D   covalent network.

4.   The chemical potential energy of the products in the reaction:

$$N_2(g) + O_2(g) \rightleftharpoons 2 NO(g)$$
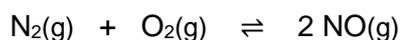
is greater than the chemical potential energy of the reactants. If the temperature of the above system, at equilibrium, were increased the mass of NO would:

A   increase and the K value would increase
B   increase and the K value would decrease
C   decrease and the K value would increase
D   decrease and the K value would decrease

5. **Which of the following describes the molecular shape and polarity respectively of an H_2S molecule?**

     A   linear and non-polar
     B   linear and polar
     C   bent and non-polar
     D   bent and polar

6. **Which of the following set of examples of the different classes of solid is correct?**

	Ionic	Polar molecular	Non-polar molecular	Covalent network	Metallic
A	KI	C_6H_5Cl	I_2	SiC	Ba
B	Na_2S	SO_2	SO_3	GaAs	Si
C	H_2SO_4	H_2SO_3	CBr_4	SiO_2	V
D	BaO	CS_2	CH_4	Si	Pb

7. **Which of the following has the lowest boiling point?**

     A   HBr
     B   HI
     C   HCl
     D   HF

8. **Which of the following statements concerning rubidium, Rb, in group 1 is false?**

     A   It has a lower melting point than sodium
     B   It forms an ionic hydride
     C   Its first ionisation energy is larger than that of potassium
     D   It will dissolve in water to form an alkaline solution

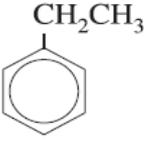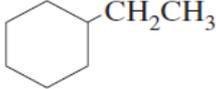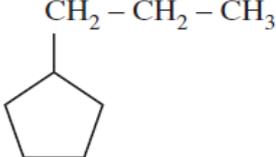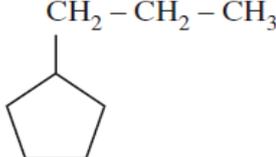9. **The table below gives four consecutive ionisation energies (in MJ mol^{-1}) of element X.**

1st	2nd	3rd	4th
1.5	7.7	8.6	9.8

     It may therefore be deduced that X is:

     A   Li
     B   Ca
     C   Al

D   Mg

10. Which of the following rows identifies the structural diagram and the corresponding correct IUPAC name of the compound with chemical formula, C_8H_{16}?

	Structural Diagram	IUPAC Name
A		ethylbenzene
B		ethylcyclohexane
C		cyclopentylpropane
D		propylcyclopentene

11. A chemist wishes to prepare a soluble fertiliser containing ions that are a source of nitrogen, phosphorus and potassium. Which one of the following mixtures of three salts will produce a completely soluble fertiliser when added to water?

A Na_3PO_4 and $Ca(NO_3)_2$ and $KC\square$

B K_2CO_3 and $Ba(NO_3)_2$ and K_3PO_4

C K_2SO_4 and $NH_4C\square$ and Na_3PO_4

D $Ca(NO_3)_2$ and KNO_3 and Na_3PO_4

12. **CCl_4 and CH_4 are structurally similar yet CCl_4 is a liquid at room temperature and CH_4 is a gas at room temperature. This is because:**

A   methane molecules can form hydrogen bonds
B   tetrachloromethane has stronger dispersion forces
C   chlorine is more electronegative than hydrogen
D   tetrachloromethane has stronger dipole-dipole forces

13. In which of the following reactions is the underlined substance acting as a base?

A $\underline{CH_3NH_2}(aq)$ + $CH_3COOH(l)$ $\rightarrow$ $CH_3NH_3^+(aq)$ + $CH_3COO^-(aq)$

B $\underline{NH_4^+}(aq)$ + $OH^-(aq)$ $\rightarrow$ $NH_3(g)$ + $H_2O(l)$

C $2\underline{Na}(s)$ + $2H_2O(l)$ $\rightarrow$ $2Na^+(aq)$ + $2OH^-$ + $H_2(g)$

  D $\underline{Cr_2O_7{}^{2-}}$(aq) + $2OH^-$(aq) → $2CrO_4{}^{2-}$(aq) + H_2O(l)
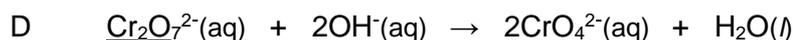
14. Ethanoic acid is classified as a weak acid. What does this mean?

  A It is only sparingly soluble in water, resulting in a low concentration of molecules
  B Its molecules hydrolyse in water solution to produce hydrodronium ions
  C Its molecules do not react with any known acid-base indicator
  D Its molecules have only a slight tendency to ionise in water solution

15. In aqueous solution, an equilibrium exists between dichromate and chromate ions as represented in the following equation:

  $Cr_2O_7{}^{2-}$(aq) + $2OH^-$(aq) ⇌ $2CrO_4{}^{2-}$(aq) + H_2O(aq) $\Delta H = -97$ kJ

If concentrated sulfuric acid is added to an equilibrium system of chromate and dichromate ions then:

  A the equilibrium position shifts to the left.
  B the equilibrium position shifts to the right.
  C there is no change in the equilibrium position.
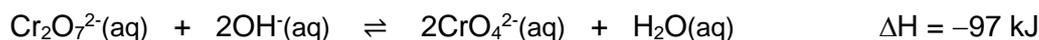 D green chromium (III) sulfate forms.

16. The combustion of butane can be described by the equation

  C_4H_{10}(g) + $6\frac{1}{2}\ O_2$(g) → $4\ CO_2$(g) + $5\ H_2O$(l) $\Delta H = -2880$ kJmol^{-1}
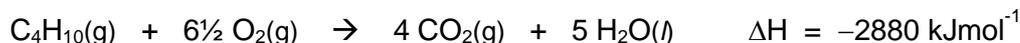
In this reaction:

  A 2880 kJ of energy is absorbed for each mole of butane that reacts.
  B 2880 kJ of energy is released for each mole of oxygen that reacts.
  C 1440 kJ of energy is absorbed for each mole of water that is produced.
  D 720 kJ of energy is released for each mole of carbon dioxide that is produced

17. **The number of non-bonding valence electron pairs (lone pairs) in dinitrogen pentoxide, N_2O_5 ($O_2N–O–NO_2$), is:**

  A **10**
  B **12**
  C **14**
  D **16**

18. Measured at constant temperature, the rate of reaction between magnesium and hydrochloric acid decreases as the reaction proceeds because:

  A the reactant concentrations decrease with time.
  B the forward and reverse reaction rates approach zero as equilibrium is reached.
  C the proportion of reactant particles with energies in excess of the activation energy decreases as the reaction proceeds.
  D absorption of heat by the reaction diminishes the reaction rate.

19. Methanol is made from $CO(g)$ and $H_2(g)$ as follows:

$$CO(g) \ + \ H_2(g) \ \rightleftharpoons \ CH_3OH(g) \ + \ 93 \ kJ$$
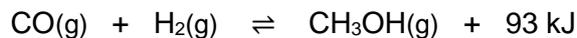
Which of the following changes would lead to an increase in the <u>rate</u> of the forward reaction, <u>once equilibrium had been re-established</u>?

      I   raising the temperature
      II   reducing the volume of the container
      III   adding more CO
      IV   adding methanol to the container

A   II and III only
B   I, II and III only
C   I, II and IV only
D   all of them

20. The following graph represents the partial pressures of SO_2 and SO_3 in the reaction shown below.

$$SO_2(g) \ + \ NO_2(g) \ \rightleftharpoons \ SO_3(g) \ + \ NO(g) \qquad \Delta H = - \ 42 \ kJ$$
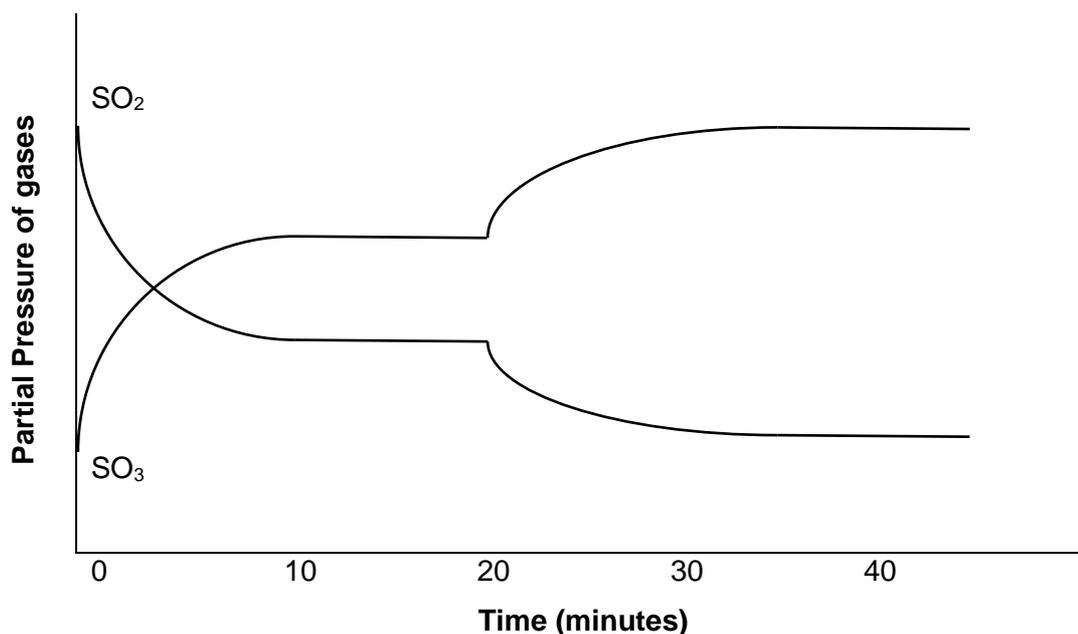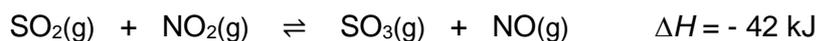
At the 20 minute mark, what changes could have been made to the system to produce the effect shown by the graph?

A   The system temperature is increased or NO is added to the system at constant volume.

B   The system temperature is increased or NO_2 is added to the system at constant volume.

C   The system temperature is decreased or NO is removed from the system at constant volume.

D   The system temperature is decreased or NO_2 is removed from the system at constant volume.

21.   Acidified potassium permanganate will cause successive oxidation reactions involving three of the substances shown below. The correct order for the three substances, from initial reactant to intermediate product to final product, is

I $CH_3CH_2CH_2CH_2OH$

II $CH_3CH_2CH_2C{\Large\diagup}^{O}_{\diagdown H}$

III $CH_3CH_2CH_2C{\Large\diagup}^{O}_{\diagdown OH}$

IV $CH_3CH_2CCH_3$ with $\|$ and O below
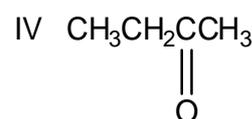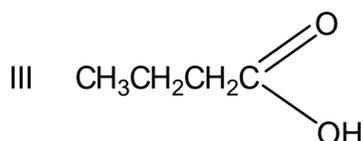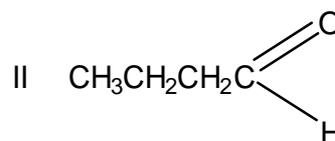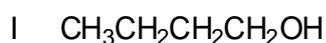
A   I, II and IV
B   III, II and I
C   I, II and III
D   I, IV and III

Question 22 refers to the energy profile diagram for the reaction shown below.

E_p

$H_2(g) + I_2(g)$

$2HI(g)$

C

B

A

Reaction coordinate
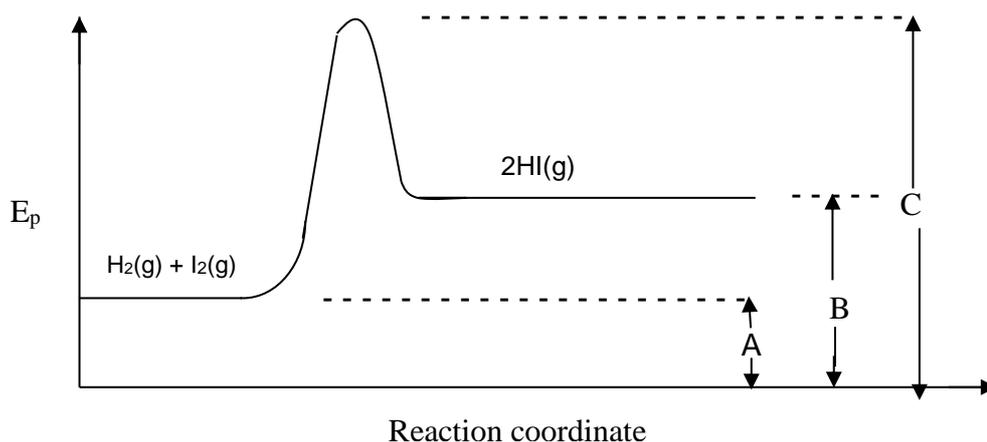
22.   For the reaction $H_2(g) + I_2(g) \rightarrow 2HI(g)$, which of the following is true?

A   It is an endothermic reaction with $\Delta H = (B - A)$ and $E_a = (C - A)$

B   It is an exothermic reaction with $\Delta H = (C - A)$ and $E_a = (C - B)$

C   It is an endothermic reaction with $\Delta H = (A - B)$ and $E_a = C$

D   It is an endothermic reaction with $\Delta H = B$ and $E_a = (C - A)$

23.   **Which of the following substances would be expected to have hydrogen bonding between its own molecules?**

I CH_2O II CH_3NH_2 III CH_3OH IV CH_3F

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

24. **Which of the following best explains why sodium chloride is virtually insoluble in ethanol?**

    A **Sodium and chloride ions are not molecules and cannot form intermolecular forces with ethanol, therefore it cannot dissolve.**

    B **Although both sodium chloride and ethanol are considered polar, they are not sufficiently similar for the "like dissolves like" rule to apply.**

    C **Sodium and chloride ions do not form sufficiently strong ion-dipole forces with ethanol molecules to disrupt the sodium chloride crystal lattice and overcome the intermolecular forces between ethanol molecules.**

    D **The dispersion forces between sodium chloride and ethanol molecules are too weak to overcome the stronger hydrogen bonds between ethanol molecules.**

25.　In a titration procedure, 25.00 mL of a sodium hydroxide solution is diluted to 500.0 mL using a volumetric flask. 20.00 mL samples of this solution are then transferred by pipette to conical flasks for titration with standard hydrochloric acid from a burette. Which of the following items of glassware can be rinsed with distilled water immediately before use, without making the titrations inaccurate?

           burette　　　　　pipette　　　　　conical flask　　　　　volumetric flask

A　　　the volumetric flask and the conical flask only
B　　　the conical flask only
C　　　the burette and the pipette only
D　　　the pipette and the conical flask only

END OF SECTION 1

Section 2: Short Answer Questions   **(70 marks = 35% of paper)**

This section has **ten (10)** questions. Answer ALL questions in Section 2. 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 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 for this section is 60 minutes.

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Question 26   **(10 marks)**

Write equations for any reactions that occur in the following procedures. If no reaction occurs, write 'no reaction'.

In each case describe in full what you would observe, including any: colours; odours; precipitates (give the colour); or gases evolved (give the colour or describe as colourless).

(a)   Solid nickel carbonate is added to nitric acid.   (3 marks)

Equation   _____

Observation _____

_____

(b)   Dilute sulfuric acid is added to barium chloride solution.   (3 marks)

Equation   _____

Observation _____

_____

(c)   Propan-2-ol is added to acidified sodium dichromate solution and heated. (4 marks)

Equation   _____

_____

_____

_____

Observation _____

_____

Question 27   (9 marks)

For each species listed in the table below draw the electron dot diagram, representing all valence shell electron pairs either as : or – Also identify the molecular shape and polarity (polar or not).

Species	Electron Dot Diagram	Shape	Polarity
CO_2			
$AsCl_3$			
$ONCl$			

Question 28   (5 marks)

Identify the most important (i.e. strongest) forces of attraction (bonds) that determine the melting point of the following solids:

(a) NH_4Cl _____

(b) SO_3 _____

(c) CH_3OH _____

(d) SiC _____

(e) CH_3I _____

Question 29   **(4 marks)**

Sketch graphs that depict the following trends:

(a)   Electronegativity of the period 3 elements   (1 mark)

Electronegativity

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|_____
        Na   Mg   Al   Si   P   S   Cl
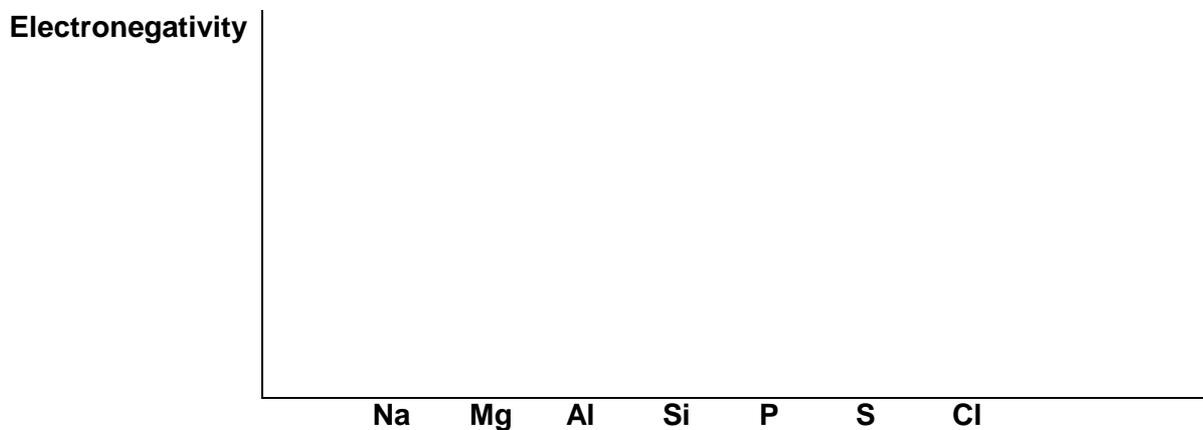
(b)   Atomic radius of the period 3 elements   (1 mark)

Atomic radius

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|_____
        Na   Mg   Al   Si   P   S   Cl
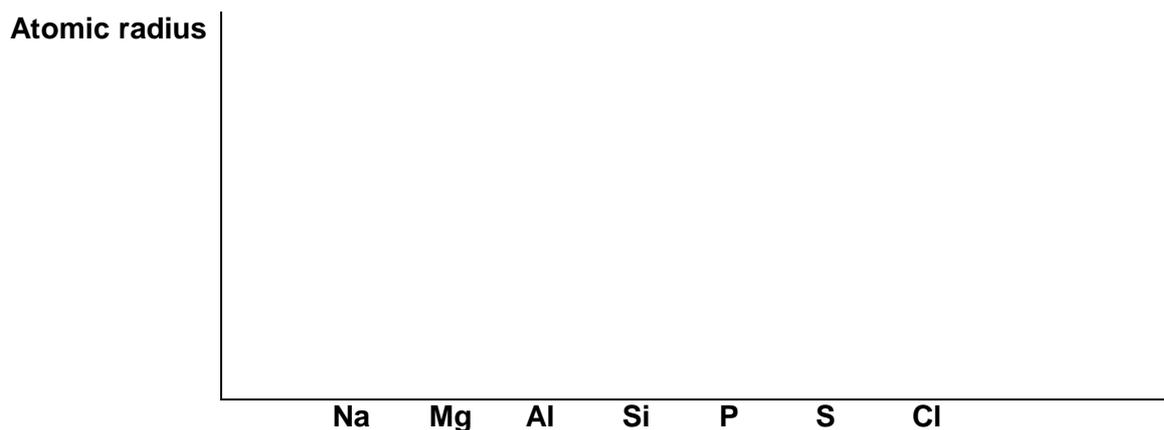
(c)   First ionisation energies of elements carbon to magnesium.   (2 marks)

**First
ionisation
energy**

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|_____
        C   N   O   F   Ne   Na   Mg
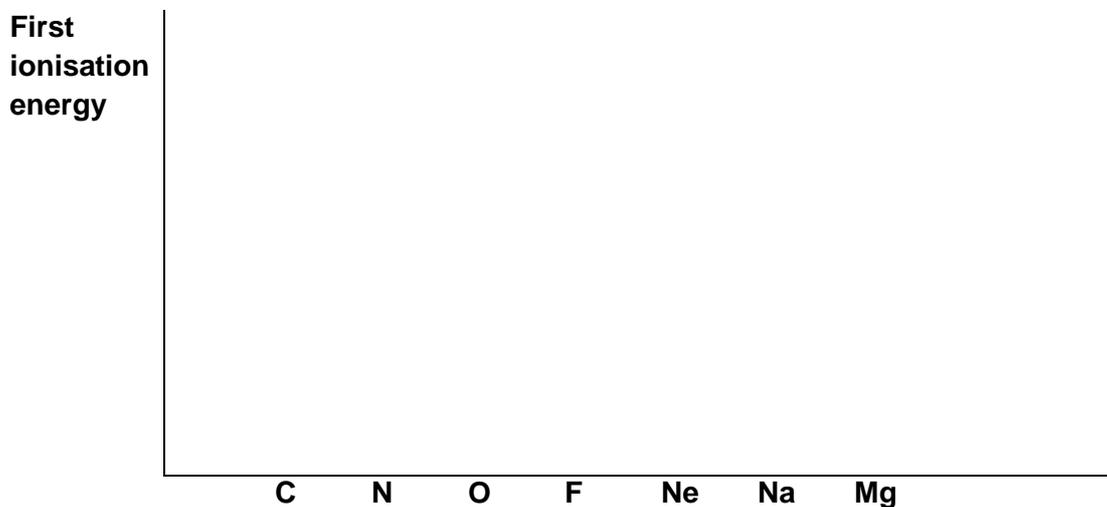
Question 30   **(10 marks)**

Explain each of the following:

(a) SiO_2 **(quartz) melts at 2700°C while CO_2 has a melting point of –57°C.**   **(2 marks)**

(b)   **Ethanol, C_2H_5OH, and propane, C_3H_8, have a similar molecular mass however, propane boils at -42.1°C while ethanol boils at 78.3°C.**   **(2 marks)**

(c)   **Sodium has a higher melting point (98°C) than potassium (63°C).**

         (3 marks)

(d)   **Petrol is a better solvent for removing oil stains then water.**

         (3 marks)

15

Question 31   (5 marks)

(a)   Give the appropriate conjugate partner of each of the following   (2 marks)

conjugate base of $H_2PO_4^-$ _____

conjugate acid of O^{2-} _____

(b)   Calculate the pH value of the solution obtained when 80.0 mL of 0.050 mol L^{-1} nitric acid is mixed with 20 ml of 0.100 mol L^{-1} sodium hydroxide solution.   (3 marks)

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Question 32   **(5 marks)**

(a)   **Draw** and **label** the <u>geometric</u> isomeric forms of 2-pentene (pent-2-ene).   (3 marks)

Name:	Name:

(b)   What **chemical test** could be used to distinguish between pent-2-ene and pentane? Appropriate observations are required in your answer.   (2 marks)

_____

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Question 33   **(8 marks)**

(a)   A sample of water from a salt lake contains 345 ppm of magnesium ions. Find the concentration in moles per litre of the magnesium ions, given the density of the water from the salt lake is 1.02 g/mL.   (3 marks)

(b)   A solution of hydrochloric acid of concentration 1.25 mol/L is needed for cleaning mortar from bricks. 80.0 mL of concentrated hydrochloric acid (10.0 mol/L) is available. What volume of water needs to be mixed with this concentrated acid to prepare the diluted solution needed for cleaning mortar?   (2 marks)

(c)   The amount of arsenic in a pesticide may be determined by precipitation of the arsenic as its sulfide, As_2S_3. If 0.246 g of As_2S_3 is obtained from 1.50 g of pesticide, find the percentage by mass of As in the pesticide.   (3 marks)

Question 34   **(10 marks)**

Ammonium carbamate (NH_4OCONH_2) decomposes forming ammonia and carbon dioxide, according to the following equilibrium:

$$NH_4OCONH_2(s) \rightleftharpoons 2\,NH_3(g) + CO_2(g) \qquad \Delta H = -450\ kJ\ mol^{-1}$$

(a)   Write an expression for the equilibrium constant, K.   (1 mark)

(b)   Three vessels contain an equilibrium mixture of this system, each of which is subjected to one of the changes described below. In each case, describe the effect of the change on each of the following <u>once equilibrium has been re-established</u>:   (9 marks)

   - the rate of the forward reaction (increase, decrease, no change)

   - the mass of CO_2 (increase, decrease, no change)

   - the value of the equilibrium constant, K (increase, decrease, no change)

Vessel	Change	Forward reaction rate	Mass of CO_2	Value of K
1	Increase in temperature			
2	Addition of neon gas at constant volume			
3	Increase in volume at constant temperature			

Question 35   **(4 marks)**

A white organic solid was analysed and found to have molecular formula $C_4H_6O_5$. Further tests were carried out to investigate the substance, as shown in the table below.

Test	Observation	Possible functional group
Dissolve a sample of the solid in water, add acidified potassium permanganate	Purple solution turns pale pink	
Dissolve a sample of the solid in water, add a few drops of blue litmus	Solution turns red	

(a)   Complete the table by naming or drawing a possible functional group that is consistent with each observation.   (2 marks)

(b)   Sketch a possible structural formula for the white solid in the space below. Show all atoms in your structural formula.   (2 marks)

END OF SECTION 2

Section 3: Extended Answer   **(80 marks = 40% of paper)**

This section contains **eight (8)** questions. Answer ALL questions in Section 3. Write your answers in the spaces provided.

Marks will be allocated for correct equations and clear setting out, even if you cannot complete the problem. Express your final numerical answers to three (3) significant figures where appropriate, and provide units where applicable.

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 for this section is 70 minutes.

Question 36   **(10 marks)**

2.75 g of anhydrous sodium carbonate was dissolved in distilled water, transferred carefully to a 500 mL volumetric flask, and topped up to the mark on the neck of the flask. 20 mL aliquots of this solution were titrated against a hydrochloric acid solution of unknown concentration, using methyl orange as the indicator. The results of successive titrations are given in the table below.

Titration number	1	2	3	4
Initial volume (mL)	0.00	20.15	2.25	21.80
Final volume (mL)	20.15	39.75	21.80	41.45
Titre volume (mL)				

(a)   Calculate the concentration of the sodium carbonate solution.   (2 marks)

(b)   State two desirable features that a primary standard such as sodium carbonate should have.   (2 marks)

_____

_____

_____

_____

(c)   Calculate the average titre volume using the table above.   (2 marks)

_____

_____

(d)   Find the concentration of the hydrochloric acid solution.   (4 marks)

_____

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_____

Question 37   **(10 marks)**

The main source of the metal manganese is from the ore pyrolusite, which contains manganese (IV) oxide, MnO_2. It is converted into manganese by the following two reactions.

$$3\ MnO_2\ \rightarrow\ Mn_3O_4\ +\ O_2$$

$$3\ Mn_3O_4\ +\ 8\ Al\ \rightarrow\ 4\ Al_2O_3\ +\ 9\ Mn$$
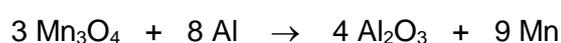
(a)   According to these equations, how many moles of manganese are produced for each mole of manganese (IV) oxide, MnO_2., that is consumed?   (1 mark)

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A 2.00 tonne sample of pyrolusite containing 73.0% MnO_2 by mass is converted into manganese by the above reactions. Note that the percentage yields of the two reactions are **83.0%** and **94.0%** respectively.

(b)   Calculate the maximum mass of Mn that could be extracted.   (4 marks)

(c)   Determine the volume of oxygen gas given off in the first reaction, measured at 500°C and a pressure of 105 kPa.   (3 marks)

(d)   Find the minimum mass of aluminium needed in the second reaction.   (2 marks)

Question 38   **(13 marks)**

Vinegar is a widely used chemical and is a 4-5% (by mass) solution of ethanoic acid, CH_3COOH. Ethanoic acid is made by the oxidation of ethanol, CH_3CH_2OH, which itself is prepared from the hydration of ethene, $CH_2=CH_2$, under special conditions. The reaction is reversible and exothermic.

$$CH_2=CH_2(g) \ + \ H_2O(g) \ \rightleftharpoons \ CH_3CH_2OH(g) \qquad \Delta H = -45 \text{ kJ mol}^{-1}$$

Below is a simple sketch that describes of the manufacture of ethanol from ethene and steam.

| 1 volume of ethene
+
0.6 volumes of steam | → | REACTION VESSEL
6000 – 7000 kPa
300°C
Phosphoric acid catalyst | → | gases cooled
so ethanol
liquefies |

unreacted gases recycled

liquid ethanol

The temperature used is 300°C with a pressure of 6000 – 7000 kPa. The pressure is maintained at this level because at higher pressures the polymerisation of ethene occurs. Although steam is a very cheap reactant, the ratio of ethene to steam is 1: 0.6 because too much steam interferes with the phosphoric acid catalyst.

(a)   Use the collision theory of reactions to explain why using a high pressure allows
          equilibrium to be attained more quickly.   (3 marks)

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(b)   State the effect the catalyst has on the yield of ethanol at equilibrium.   (1 mark)

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(c)   The graph below shows the distribution of molecular energies in the reaction vessel at 300°C. ON THESE AXES, sketch a graph to show how the distribution would change if the temperature were <u>raised</u> to some new temperature T_2.   (1 mark)

(d)   Use the graph above, and collision theory, to explain how the **rate** at which equilibrium is attained will change when the temperature of the mixture is raised.   (3 marks)

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(e)   The temperature of 300°C used for this reaction is moderate by industrial standards. With reference to the concepts of yield and rate, explain why this intermediate temperature is considered optimal for this reaction.   (3 marks)

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(f)   In the final stage, ethanol is removed from the system by condensing the vapours. The unreacted ethene does not condense, as it has a lower boiling point than ethanol. Explain what effect the condensation of ethanol has on the yield attained. (2 marks)

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Question 39   **(9 marks)**

An experiment was carried out to determine the amount of calcium carbonate present in a sample of an antacid tablet. A 1.42 g tablet was crushed and then reacted with an excess of 0.200 $molL^{-1}$ hydrochloric acid. When effervescence had ceased an excess of phosphoric acid solution was added to the solution, resulting in the formation of a precipitate of calcium phosphate ($Ca_3(PO_4)_2$). When dried, this precipitate had a mass of 0.937g.

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

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(b)   Calculate the percentage by mass of calcium carbonate in the tablet.   (5 marks)

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(c)   Calculate the minimum volume of hydrochloric acid required to completely react with the calcium carbonate in the first stage of the process.   (2 marks)

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Question 40 (12 marks)

A student conducted an investigation in which she added a certain mass of powdered zinc metal to an excess of hydrochloric acid in a filled test tube sealed by a rubber stopper. The hydrogen gas evolved was passed into a gas collection cylinder and the volume produced was recorded at regular intervals as the reaction proceeded. The results are displayed in the table below.

elapsed time (s)	0	10	20	30	40	50	60	70	80	90
volume of $H_2(g)$ (mL)	0	54	83	98	106	110	113	115	116	116

(a)   Write the ionic equation for this reaction.   (1 mark)

(b)   Graph the volume of hydrogen gas evolved versus elapsed time on the graph paper provided below.   (4 marks)

(c)   Name two variables that should be controlled to make this a fair trial.   (2 marks)

(d)   Briefly explain why your graph has the shape that it does.   (2 marks)

(e)   If the hydrogen gas was collected at a pressure of 102.9 kPa and a temperature of 22°C, then determine the mass of zinc that was reacted.   (3 marks)

Question 41   **(8 marks)**

Each year, millions of tonnes of iron ore, impure iron (III) oxide, are mined. This ore is converted to iron in the blast furnace. The overall reaction that leads to the production of iron in the blast furnace is given by the following equation:

$$Fe_2O_3(s) \ + \ 3\,CO(g) \ \rightarrow \ 2\,Fe(l) \ + \ 3\,CO_2(g)$$

In a blast furnace, 25 tonnes of iron ore (containing 87% Fe_2O_3) and 1.53×10^7 L of carbon monoxide are reacted together at a pressure of 110 kPa and a temperature of 750 K.

(a)   Determine the limiting reactant.   (5 marks)

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(b)   Calculate the mass of iron that could be produced in the reaction.   (2 marks)

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(c)   What volume of carbon dioxide would be produced in the reaction at the given temperature and pressure?   (1 mark)

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Question 42 (9 marks)

The graph below represents the concentration of reactants and products at equilibrium for the Haber Process reaction:

$$N_2(g) \ + \ 3H_2(g) \ \rightleftharpoons \ 2NH_3(g) \qquad\qquad \Delta H = -92 \ kJmol^{-1}$$
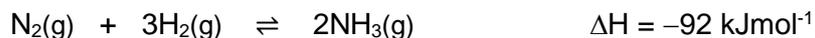
At equilibrium, there is no change in the concentrations of each component. Sketch the appropriate changes in concentrations of nitrogen and ammonia on the graph when:

(a)   at time t_1 the volume of the vessel is suddenly halved   (2 marks)

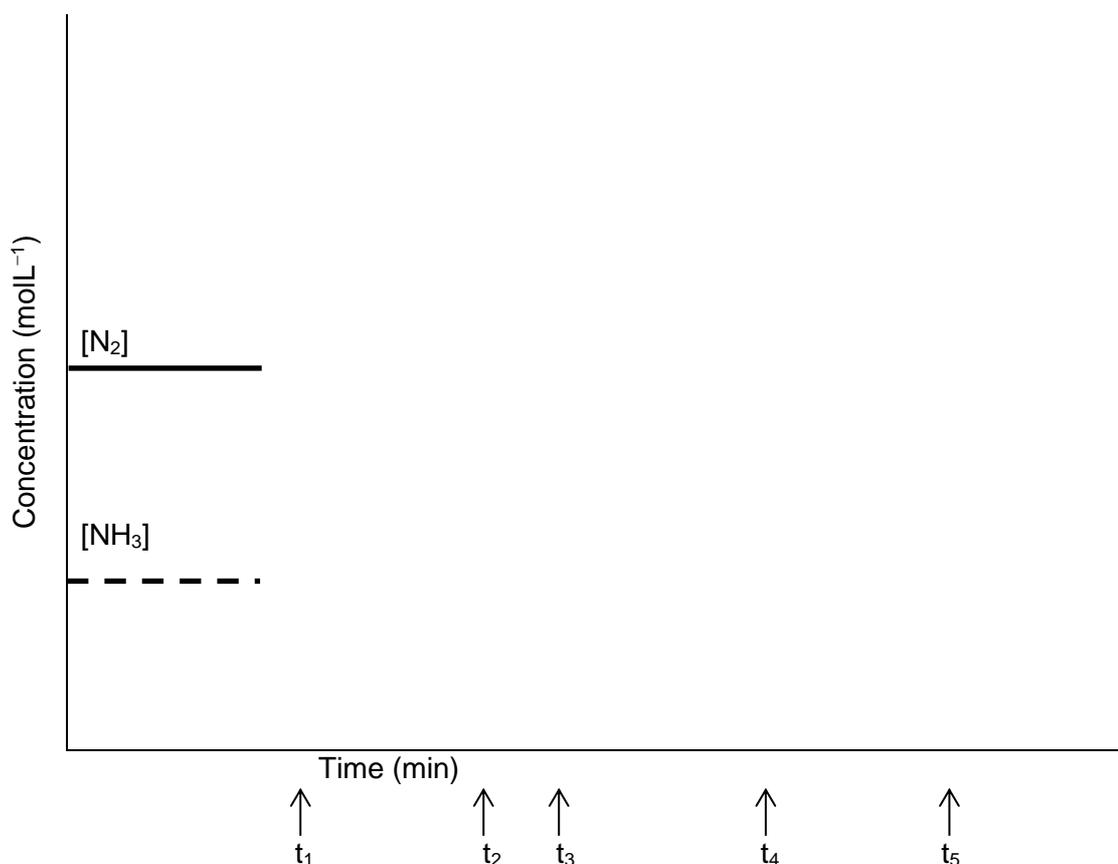(b)   at time t_2 equilibrium is restored   (2 marks)

(c)   at time t_3 the temperature is decreased   (2 marks)

(d)   at time t_4 equilibrium is restored   (1 mark)

(e)   Would the equilibrium constant after time t_4 be <u>higher</u>, <u>lower</u> or the <u>same</u> value as it had before time t_1?   (1 mark)

(f)   At time t_5, a catalyst was added to the system. State the effect (write "higher", "lower" or "same" in the boxes on the right) of this addition of a catalyst on the: (1 mark)

equilibrium concentration of NH_3	
rate of the forward reaction	
value of the equilibrium constant	

Question 43   **(9 marks)**

The elements magnesium and iodine, and the compound they form, magnesium iodide, are all solids at room temperature. However the three substances have very different properties, as outlined in the table below.

	Melting Point (°C)	Characteristics of solid	Electrical Conductivity when solid	Electrical Conductivity when molten
Mg	650	hard and malleable	high	high
I_2	114	soft	low	low
MgI_2	637	hard and brittle	low	high

Describe and explain the differences in properties between these three substances with reference to their bonding and structure.

END OF PART 3

END OF EXAMINATION

Additional Working Space