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
Formulae and Constants 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 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 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
				200	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, 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 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.

Section One: Multiple-choice   **25%   (50 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 $CHC\ell_3$?

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

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

A. X_2O

B. XO

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.   I and II only

B.   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. SiO_2

    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?

	Type of bond broken	Formula of purple species
A.	covalent	I
B.	covalent	I_2
C.	dispersion forces	I_2
D.	dipole-dipole	I_2

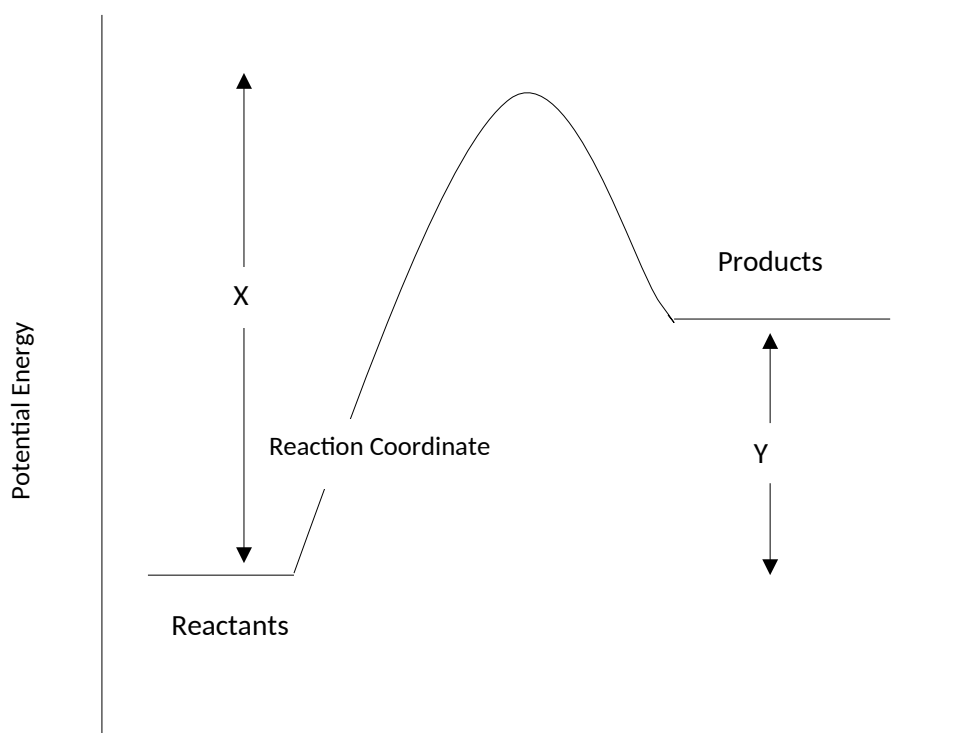6.   Which of the following statements is correct?

    A.   Covalent network solids include diamond, graphite and sulfur.

    B.   Metal solids exhibit non-directional interparticle 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 one of the following substances will have the highest melting point?

    A.   Carbon dioxide

    B.   Nitrogen dioxide

   C.   Silicon dioxide

    D.   Sulfur dioxide

8.   Which one of the following statements about the transition state in a chemical reaction is **false**?

    A.   The transition state corresponds to a point where bond breaking and bond forming is occurring.

    B.   The transition state is the highest energy state in the reaction.

    C.   The transition state is unstable and will only exist for a short period of time.

    D.   The transition state will be the same for a reaction whether a catalyst is used or not.

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.   HCℓ, HBr and HI have boiling points of -85°C, -67°C and -35°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 become more polar as they progress down a column of the Periodic Table.

    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.

11.   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.

12.   In the process for the preparation of methane:

$$C(s) + 2 H_2(g) \rightleftharpoons CH_4(g) \qquad \Delta H = -75 \text{ kJ mol}^{-1}$$
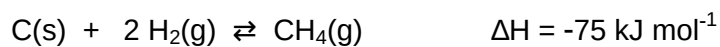
If the equilibrium system temperature is increased, what effect will this have on the equilibrium constant, K, and the yield of CH_4?

|	*Equilibrium constant, K*	*Yield of CH_4*
A.	decrease	increase
B.	decrease	decrease
C.	increase	increase
D.	increase	decrease

The next two questions, 13 and 14, refer to the equation below which shows bromine dissolving in water. Assume that the reaction is at equilibrium.

$$Br_2(aq) + H_2O(l) \rightleftharpoons H^+(aq) + Br^-(aq) + HOBr(aq)$$
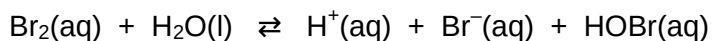
*red   colourless*

13. What observation would you expect if concentrated acid such as hydrochloric acid is added to the system at equilibrium?

    A.   No observable change.

    B.   The solution would become colourless.

    C.   The solution would become darker red.

    D.   The solution would become lighter red.

14. Which one of the following would **not** cause the reaction to shift to the right?

    A.   Addition of Br^- ions to the system.

    B.   Decreasing the $[H^+]$.

    C.   Addition of Br_2.

    D.   Addition of H_2O.

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

    $$2 H_2(g) + O_2(g) \rightleftharpoons 2 H_2O(g)$$ is equal to 2×10^{81} at $25^{\circ}C$.
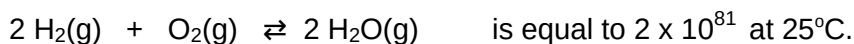
    This value suggests that:

    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.

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

$$Fe^{3+}(aq) \quad + \quad SCN^-(aq) \quad \rightleftarrows \quad Fe(SCN)^{2+}(aq) + HEAT$$
*yellow*   *colourless*   *red*
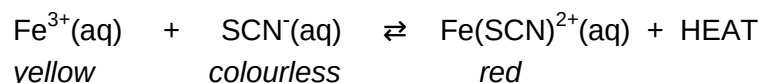
The test tubes appear orange due to the relative colours of the three ions.

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)

	Imposed change	*Colour at the new equilibrium*
A.	Some NaSCN(s) is added and it dissolves into its ions.	Solution becomes more red.
B.	Some $AgNO_3$(s) is added, it dissolves and a white solid AgSCN forms.	Solution becomes more red.
C.	Some NaOH(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.

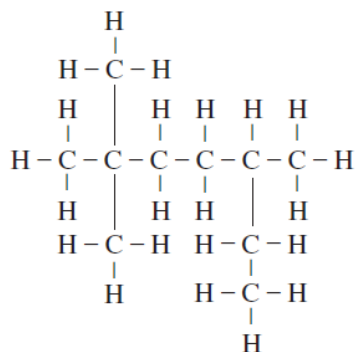**The next two questions, 17 and 18, refer to the following information:**

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:

$$CO(g) \quad + \quad 2 H_2(g) \quad \rightleftarrows \quad CH_3OH(g) \qquad \Delta H = -91 \text{ kJ mol}^{-1}$$
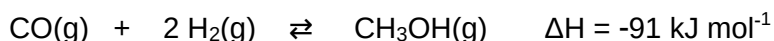
17.   Which of the following conditions would favour the highest yield of the product methanol?

A.   low temperature and high pressure.

B.   low temperature and low pressure.

C.   high temperature and low pressure.

D.   high temperature and high pressure.

18.   What is the likely function of the ZnO and Cr_2O_3?

A.   These conduct away the heat and help favour the forward reaction.

B.   These absorb the alcohol formed so it can be evaporated off later.

C.   These transition metal oxides lower the ΔH of the reaction making it go faster.

D.   These may be catalysts that enable equilibrium to be achieved faster.

19.   The IUPAC name for the structure below is:

$$
\begin{array}{c}
H \\
| \\
H-C-H \\
H \quad | \quad\quad H\ \ H\ \ H\ \ H \\
| \quad\quad | \quad\ | \ \ \ | \ \ \ | \\
H-C-C-C-C-C-C-H \\
| \quad\quad | \quad\ | \quad\quad | \\
H \quad | \quad\ H\ \ H\quad | \quad H \\
H-C-H \ \ H-C-H \\
| \quad\quad\quad\quad | \\
H \quad\quad\quad\quad H-C-H \\
\quad\quad\quad\quad\quad\quad | \\
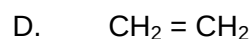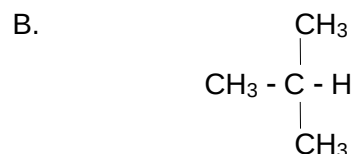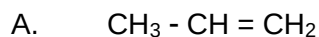\quad\quad\quad\quad\quad\quad H
\end{array}
$$

A.   2,2,5-trimethylheptane

B.   3,6,6-trimethylheptane

C.   2-ethyl-5,5-dimethylhexane

D.   5-ethyl-2,2-dimethylhexane

20.   Which of the following compounds is saturated?

A. CH_2CH_2

B. CH_3CHCH_2

C. C_6H_6

D. $(CH_3)_3CH$

21.   Naphthalene $C_{10}H_8$ is an unsaturated cyclic hydrocarbon which undergoes a substitution reaction with Br_2. One of the products from this reaction would be:

A. H_2

B.   HBr

C. $C_{10}H_8Br$

D. $C_{10}H_8Br_2$

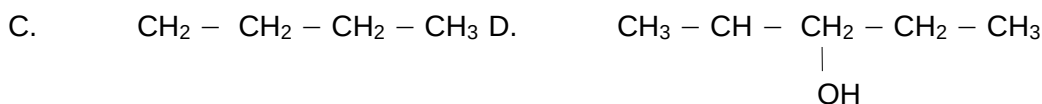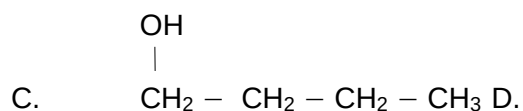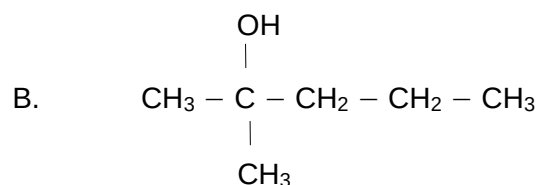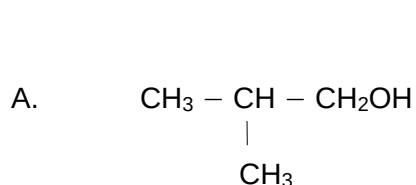22.   An organic compound is a gas at room temperature.

When it is bubbled into bromine water, the bromine water decolourises readily, indicating bromine has reacted with the hydrocarbon.

When 1 mole of the compound is burned completely in oxygen, 2 moles of CO_2 are produced.

Which of the following formulae is consistent with all these observations?

A. $CH_3 - CH = CH_2$ B.
$$CH_3 - \overset{\overset{\displaystyle CH_3}{|}}{\underset{\underset{\displaystyle CH_3}{|}}{C}} - H$$

C. $BrCH_2 - CH_2Br$ D. $CH_2 = CH_2$

23.   Which one of the following alcohols is a secondary alcohol?

A. $CH_3 - \overset{}{\underset{\underset{\displaystyle CH_3}{|}}{CH}} - CH_2OH$ B. $CH_3 - \overset{\overset{\displaystyle OH}{|}}{\underset{\underset{\displaystyle CH_3}{|}}{C}} - CH_2 - CH_2 - CH_3$

C. $\overset{\overset{\displaystyle OH}{|}}{CH_2} - CH_2 - CH_2 - CH_3$ D. $CH_3 - CH - \underset{\underset{\displaystyle OH}{|}}{CH_2} - CH_2 - CH_3$

24.   The compound below is the product of an oxidation reaction with acidified potassium permanganate.

$$\underset{\underset{\displaystyle CH_3}{|}}{\overset{\overset{\displaystyle CH_3}{|}}{CH}} - CH_2 - \overset{\overset{\displaystyle O}{||}}{C} - H$$
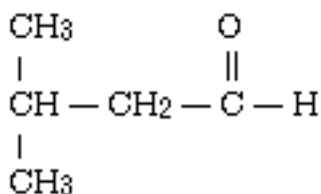
The name of the compound that was oxidised is:

A.   2-methylbutan-1-ol.
B.   1,1-dimethylpropan-3-ol.
C.   3-methylbutan-1-ol.
D.   1-methylbutanal.

The next question 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 inter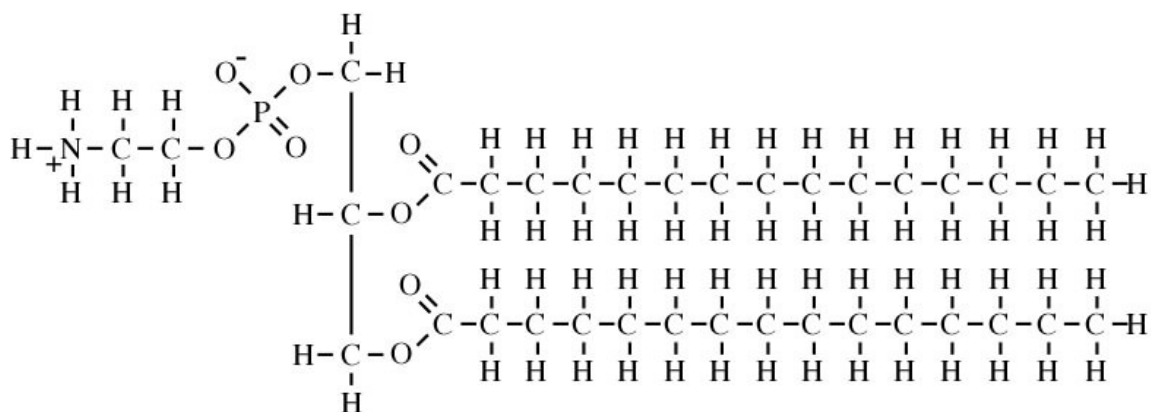esting in that it is a bipolar molecule with a negatively charged oxygen atom and positively charged nitrogen atom found within the overall neutral molecule. An organic chemist wishing to show its structure might show it as in the diagram below:

25.   What is seen in the structure of lecithin that enables 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 **eleven (11)** questions. Answer **all** questions. Write your answers in the space provided.

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

Consider the following system:

$$CO(g)   + 2 H_2(g) \rightleftarrows CH_3OH(g)   K = 2.34 \times 10^{-1} \text{ at } 25^{\circ}C$$
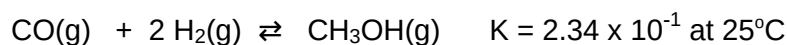
(a)   If at $58^{\circ}C$, $K = 4.56 \times 10^{-2}$ (4 marks)

Is this reaction exothermic or endothermic? _____

Explain your answer:

_____

_____

_____

_____

_____

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

Change	Effect on rate	Effect on yield
Increasing the pressure of the system		
Adding a catalyst		
Decreasing the temperature		

Question 27 **(10 marks)**

Give the names and the structures of all the isomers of C_3H_5Br.

Structure	IUPAC name

Question 28   (10 marks)

Draw structural formulae and give the IUPAC name for the organic compounds which match the descriptions in (a) to (e). Show all atoms in the structural formulae.

Description	Structure	IUPAC Name
(a) The product of the reaction between propene and bromine solution		
(b) The organic product formed when the alcohol, pentan-2-ol, is oxidised with acidified potassium permanganate solution.		
(c) An isomer of pentan-2-ol that can react with excess potassium permanganate solution to form pentanoic acid.		
(d) The pentanoic acid formed in (c) is then mixed with ethanol, a few drops of concentrated sulfuric acid are added and the mixture is warmed		
(e) Give structure and name of an isomer of pentan-2-ol that will not react with the potassium permanganate solution.		

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 $Ag^+(aq)$], molecules [for example $NH_3(g)$, $NH_3(aq)$, $CH_3COOH(l)$] or solids [for example $BaSO_4(s)$, $Cu(s)$, $Na_2CO_3(s)$].

(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 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)

        $Cu(s) + 4 H^+(aq) + 2 NO_3^-(aq) \rightarrow Cu^{2+}(aq) + 2 H_2O(l) + 2 NO_2(g)$

Observation: _____

_____
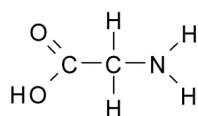
Question 31   **(6 marks)**

(a)   Draw a piece of polymer formed from the monomer 2-chloropropene.
        Show at least 3 monomer units.   (2 marks)

(b)   Draw a piece of polymer formed from the monomer glycine $H_2C(NH_2)COOH$;
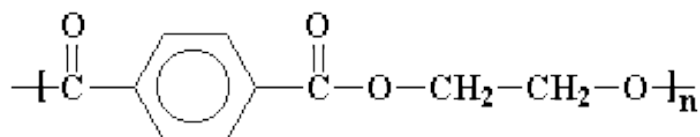

        Show at least 3 monomer units.   (2 marks)

(c)   Draw the structures of the two monomers that were used to make this polymer:

                                                                    (2 marks)

Monomer 1	Monomer 2

Question 32 **(6 marks)**

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

Molecule or ion	Structural formula	Shape
H_2CO		
$SO_3{}^{2-}$		
CS_2		

Question 33 **(6 marks)**

Using the information in the table below, identify the substances A to F from the following list:

aluminium	calcium carbonate	copper	copper (II) carbonate
octane	graphite	iodine	potassium chloride
nickel (II) chloride	silicon dioxide	mercury	

	Electrical conductivity in the solid state	Electrical conductivity in the liquid state	Solubility in water	Phase at 25°C	Colour at 25°C	Name of substance
A	nil	conducts	soluble	solids	white	
B	conducts	conducts	insoluble	solid	silver	
C	nil	nil	insoluble	liquid	colourless	
D	nil	nil	insoluble	solid	white	
E	conducts	conducts	insoluble	liquid	silver	
F	nil	n/a	insoluble	solid	green	

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. If the temperature is raised to 68°C, redraw the distribution curve. A catalyst was also added. Show on the diagram the catalyzed activation energy.
.
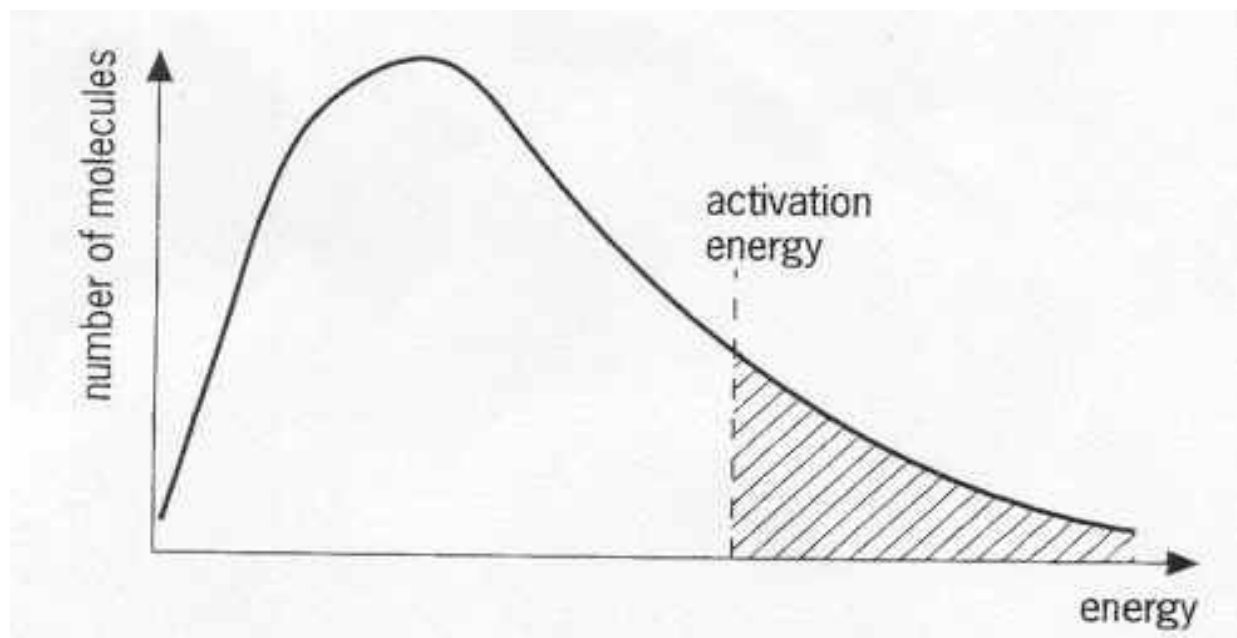
Explain, using the above diagram, how the rate of reaction is affected with increased temperature and addition of a catalyst.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

Question 35   **(4 marks)**

The melting points (^{o}C) of the oxides of four consecutive elements of period 3 are as follows:

| 2852 | 2050 | 1725 | 300 |

Give the formula of the oxides with the melting points of 2852°C and 1725°C.   (2 marks)

Melting point	Formula of oxide
2852°C	
1725°C	

Give a brief explanation of your choices: (2 marks)

_____

_____

_____

_____

_____

_____

_____

Question 36   **(3 marks)**

Explain why the removal of a certain glue stuck on a desk was achieved by using ethanol but not petrol.

_____

_____

_____

_____

_____

_____

_____

_____

End of Section Two

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

This section contains **five (5)** 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: 55 minutes.

_____

Question 37   **(22 marks)**

The second stage in the manufacture of sulphuric acid is the Contact Process, which involves the oxidation of sulphur dioxide into sulphur trioxide.

$$2\ SO_2(g)\ +\ O_2(g)\ \rightleftarrows\ 2\ SO_3(g)\qquad \Delta H = \text{-190 kJ mol}^{-1}$$

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)
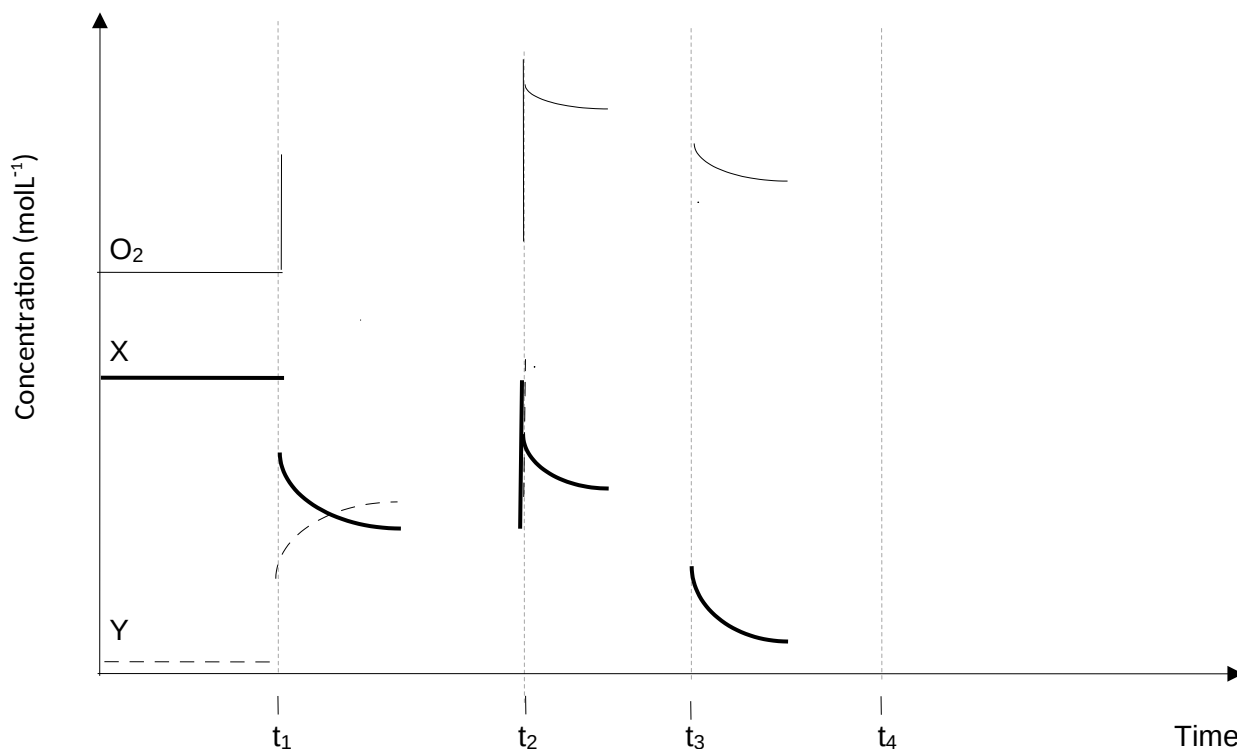
Question 37 continued

(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 37 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 Contact Process is repeated below:

$$2 SO_2(g) \; + \; O_2(g) \; \rightleftarrows \; 2 SO_3(g) \qquad \Delta H = \text{-190 kJ mol}^{-1}$$

(8 marks)

This page has been intentionally left blank

Question 37 continued

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

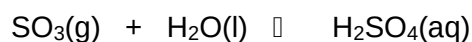Step 1   Mining of "pyrite ore", which contains, by mass, 73% FeS_2.

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

$$4\,FeS_2(s)\ +\ 11\,O_2(g)\ \to\ 2\,Fe_2O_3(s)\ +\ 8\,SO_2(g)$$

Step 3   The Contact Process, which is only 68% efficient.

$$2\,SO_2(g)\ +\ O_2(g)\ \rightleftharpoons\ 2\,SO_3(g)\qquad\quad \text{(68\% efficient)}$$

Step 4   Reaction of sulphur trioxide with water to form sulphuric acid

$$SO_3(g)\ +\ H_2O(l)\ \to\ H_2SO_4(aq)$$

(c)   Calculate the mass of sulphuric acid that can be produced from 1 tonne (1000 kg) of "pyrite ore".
        (You may assume that all other reactions are 100% efficient)

                                                                                        (7 marks)

Question 37 continued

(e)   The commercial concentrated sulphuric acid produced in the above process has a
       concentration of 18 mol L^{-1}. Using the above quantities, what volume of this acid can be
       formed?

                                                                                    (2 marks)

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

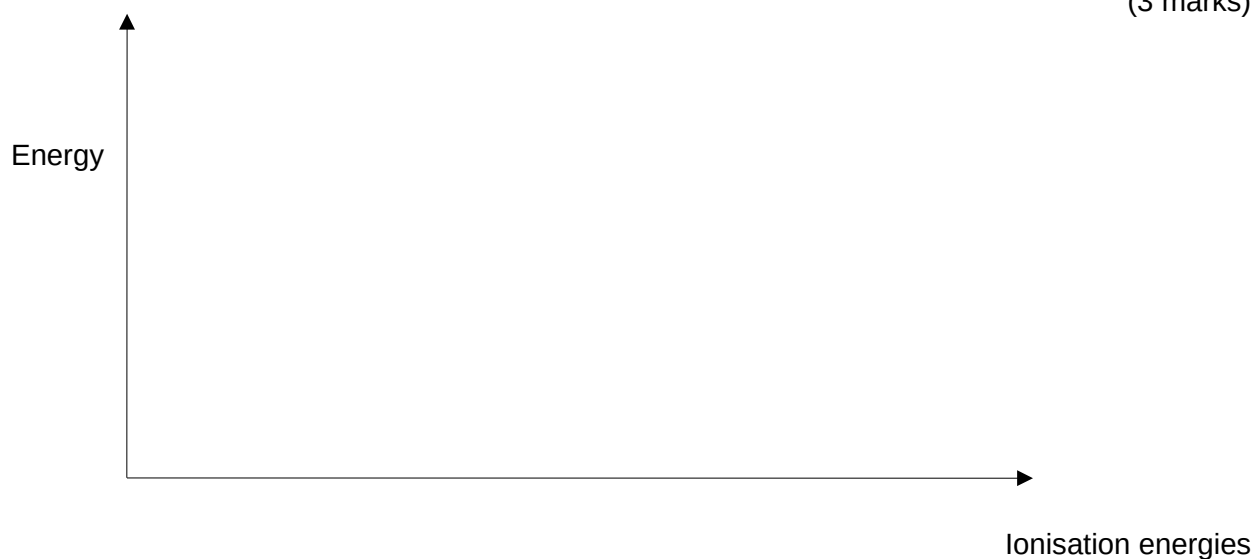**Question 38**   **(14 marks)**

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)

Energy

Ionisation energies

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

_____

_____

_____

_____

_____

_____

_____

_____

_____

Question 38 continued

(d)   Which will have the higher 1st ionisation energy, sodium or potassium? Explain.

(3 marks)

_____

_____

_____

_____

_____

_____

_____

_____

_____

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

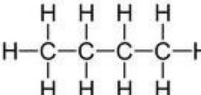Order: *lowest* _____*highest*

Explanation

:_____ \

_____

_____

_____

_____

_____

_____
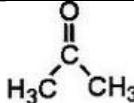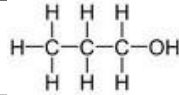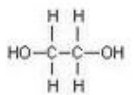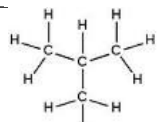
_____

Question 39   **(14 marks)**

(a)   Consider the organic compounds in the table below. Using your knowledge of structure and bonding, arrange these compounds in order of decreasing boiling point in the table below.

(3 marks)

Substance	Name	molar mass	Boiling point (1= highest, 5= lowest)
	butane	58	
	propanone	58	
	propan-1-ol	60	
	ethane-1,2,diol	62	
	methylpropane	58	

(b)   In the space below give your reasoning for your choices in (a).   (6 marks)

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

Question 39 continued

(c)   The simplest amino acid, glycine, has the formula H_2NCH_2COOH.

    (i)   In the previous list of decreasing boiling points, whereabouts would you expect
        glycine to be positioned?   Explain your reasoning.

                                                                                                        (2 marks)

    (ii)   Predict the shapes of the arrangement of the bonds around each of the atoms
        highlighted in bold in the table below:

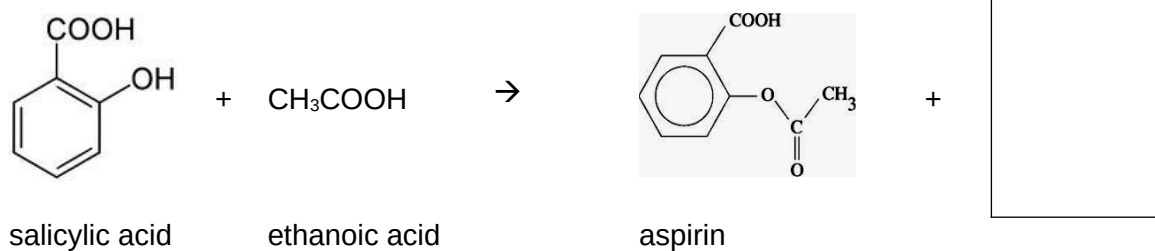   (3 marks)

	Shape
$H_2\mathbf{N}CH_2COOH$	
$H_2N\mathbf{C}H_2COOH$	
$H_2NCH_2\mathbf{C}OOH$	

Question 40   **(13 marks)**

Aspirin can be manufactured using the following reaction:

salicylic acid   ethanoic acid   aspirin

(a)   Complete the equation by filling in the box above.   (1 mark)

(b)   Name the two main functional groups in aspirin.   (2 marks)

_____ and _____

In a particular production of aspirin, 100.0 g of salicylic acid is reacted with 50.0 g of ethanoic acid.

(c)   Identify the limiting reactant.   (4 marks)

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

Question 40 continued

(d)   Calculate the mass of aspirin that can be produced, assuming the process is 100% efficient.   (2 marks)

_____

_____

_____

_____

_____

(e)   Calculate the mass of excess reactant remaining after the reaction.   (2 marks)

_____

_____

_____

_____

_____

(f)   Aspirin tablets normally contain 300.0 mg of aspirin. Assuming that it is totally soluble, what would be the concentration of aspirin in the blood, in mg L^{-1}, of an average human with 4.70 L of blood if he took two aspirin tablets.   (2 marks)

_____

_____

_____

_____

_____

_____

_____

_____

Question 41   **(17 marks)**

An unknown alpha amino acid, X, 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 1.47 g of water were formed.

2nd experiment   1.68 g of X was reacted so as to convert all the nitrogen into nitrogen gas (N_2). It was found that the gas formed occupied 211 mL, measured at S.T.P.

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)

Question 41 continued

(b)   Calculate the molecular formula of X.   (3 marks)

_____

_____

_____

_____

_____

_____

_____

(c)   Using your knowledge of the structure of alpha amino acids, draw the only possible
         structural formula of X.   (2 marks)

End of Examination

Additional working space