NATIONAL JUNIOR COLLEGE
SH2 PRELIMINARY EXAMINATION

Higher 1

CANDIDATE NAME

SUBJECT CLASS

REGISTRATION NUMBER

CHEMISTRY

8872/01

Paper 1 Multiple Choice

Thursday 14 Sept 2017
50 minutes

Additional Materials: Multiple Choice Answer Sheet
Data Booklet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid.
Write your name, subject class and registration number on the Answer Sheet in the spaces provided unless this has been done for you.

There are **30** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

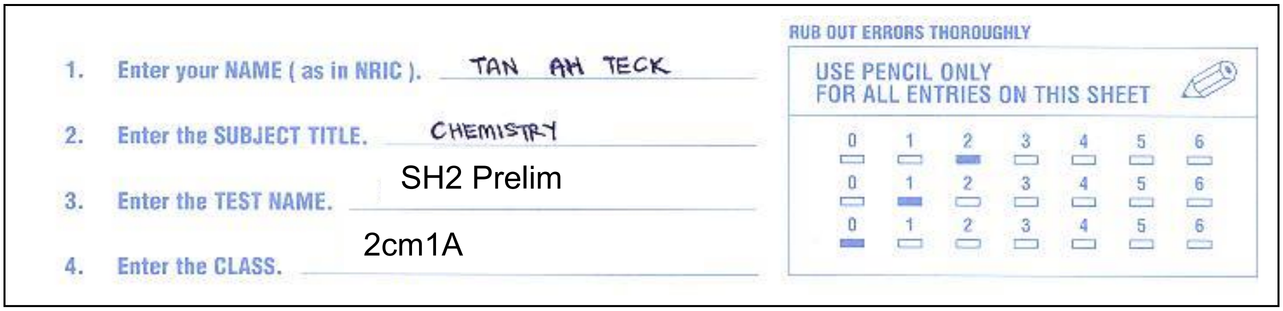
Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.

The use of an approved scientific calculator is expected, where appropriate.

This paper consists of **14** printed pages

Instructions on how to fill in the Optical Mark Sheet



RUB OUT ERRORS THOROUGHLY

1. Enter your NAME (as in NRIC). TAN AH TECK
2. Enter the SUBJECT TITLE. CHEMISTRY
3. Enter the TEST NAME. SH2 Prelim
4. Enter the CLASS. 2cm1A

USE PENCIL ONLY
FOR ALL ENTRIES ON THIS SHEET

0 1 [✓ 2] 3 4 5 6
0 [✓ 1] 2 3 4 5 6
[✓ 0] 1 2 3 4 5 6

Example:

Shade the index number in a 5 digit format on the optical mark sheet: 2nd digit and the last 4 digits of the Registration Number.

Student	Examples of Registration No.	Shade:
	1<u>6</u>0<u>5648</u>	65648

Section A

For each question there are four possible answers **A**, **B**, **C**, and **D**. Choose the **one** you consider to be correct.

1 How many molecules are present in 5 cm^3 of methane under room conditions?

A $\dfrac{5 \times 24000}{6.02 \times 10^{23}}$

B $\dfrac{5 \times 6.02 \times 10^{23}}{24000}$

C $5 \times 6.02 \times 10^{23} \times 24000$

D $\dfrac{24000}{5 \times 6.02 \times 10^{23}}$

2 Ions of the two most common isotopes of iron are shown below:

$$^{54}_{26}\mathrm{Fe}^{2+} \qquad ^{56}_{26}\mathrm{Fe}^{2+}$$

Which statement is true?

A Both of these Fe^{2+} ions have the same number of electrons but different number of protons.

B The $^{54}_{26}\mathrm{Fe}^{2+}$ ion will be deflected more than the $^{56}_{26}\mathrm{Fe}^{2+}$ ion when passing through an electric field of same strength.

C The $^{56}_{26}\mathrm{Fe}^{2+}$ ion have more protons than the $^{54}_{26}\mathrm{Fe}^{2+}$ ion.

D The electron arrangement of both these Fe^{2+} ions is $1s^2 2s^2 2p^6 3s^2 3p^6 3d^4 4s^2$.

3 10 cm^3 of a hydrocarbon C_xH_y was exploded in 100 cm^3 of oxygen gas and cooled to room temperature. There was a contraction of 30 cm^3. When the resulting gas was passed through a solution of sodium hydroxide, there was a further contraction of 40 cm^3. All volumes measured are under room conditions.

What is the molecular formula of the hydrocarbon?

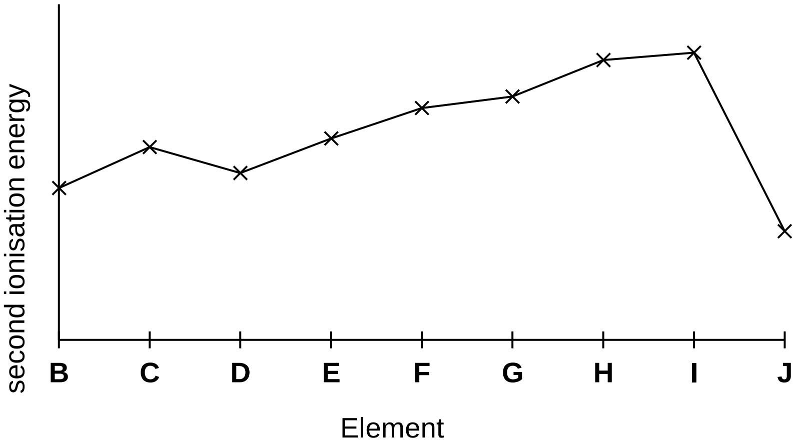
A C_4H_8

B C_4H_{10}

C C_3H_6

D C_3H_{10}

4 The following graph represents the second ionisation energy trend of 9 consecutive elements in Periods 3 and 4.



Which statement is correct?

A Element **C** is in Group 3.

B Element **F** has the lowest boiling point.

C The ionic radius of ion of **E** is greater than that of ion of **J**.

D The formula of the compound formed between elements **D** and **G** is $\mathbf{D_2G_3}$.

5 Two elements, **X** and **Y**, have the following properties.

- **X** and **Y** form ionic compounds Ca**X** and Ca**Y** respectively.
- Element **X** forms **X**F_6 molecule while **Y** is unable to do so.

Which options shows the correct electronic configuration of **X** and **Y**?

	X	**Y**
A	[Ne] $3s^2\ 3p^2$	[He] $2s^1$
B	[Ne] $3s^2\ 3p^4$	[He] $2s^1$
C	[Ne] $3s^2\ 3p^2$	[He] $2s^2\ 2p^4$
D	[Ne] $3s^2\ 3p^4$	[He] $2s^2\ 2p^4$

6 For which system does the equilibrium constant, K_c, have units of $mol^{-2}dm^6$?

A $CH_3CH_2OH(l) + CH_3COOH(l) \rightleftharpoons CH_3COOCH_2CH_3(l) + H_2O(l)$

B $NH_3(aq) + H_2O(l) \rightleftharpoons NH_4^+(aq) + OH^-(aq)$

C $N_2(g) + 3H_2(g) \rightleftharpoons 2\ NH_3(g)$

D $2CrO_4^{2-}(aq) + 2H^+(aq) \rightleftharpoons Cr_2O_7^{2-}(aq) + H_2O(l)$

7 Which compound is the most volatile?

A $CH_3CH_2CH_2CH_2NH_2$

B $CH_3CH(CH_3)CH_2NH_2$

C $CH_3CH(NH_2)CH_2CH_3$

D $CH_3C(CH_3)_2NH_2$

8 Which reaction has a positive ΔH value?

A $Na(s) \rightarrow Na(g)$

B $OH^-(aq) + H^+(aq) \rightarrow H_2O(l)$

C $2\,Cl(g) \rightarrow Cl_2(g)$

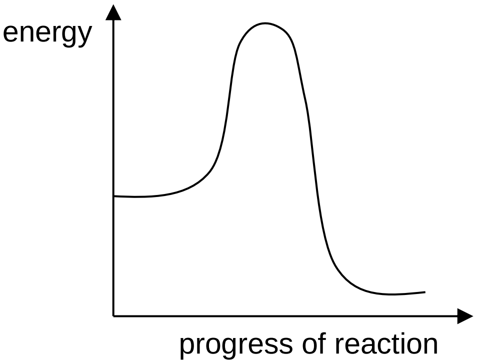
D $CH_4(g) + O_2(g) \rightarrow CO_2(g) + H_2O(l)$

9 A series of reactions between 2**X** and **Y** to give **Z** is shown below, where the overall enthalpy change of reaction is negative.

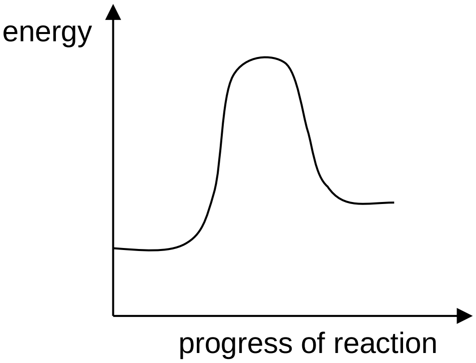
Step 1: **X** + **Y** → **U**
Step 2: **X** + **U** → **Z**

Which diagram represents the energy profile diagram of the reaction?

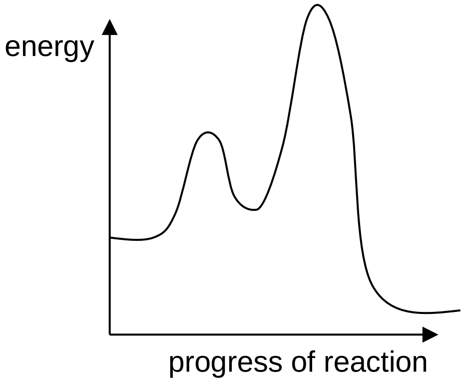
A



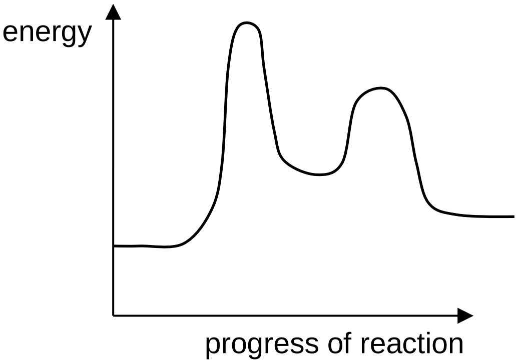
C



B



D



10 The bond dissociation energy of H–C*l* is +432 kJ mol^{-1}.

Which of the following processes have an enthalpy change of −432 kJ mol^{-1}?

A $HCl\,(s) \rightarrow H(g) + Cl(g)$

B $HCl\,(g) \rightarrow H(g) + Cl(g)$

C $H(g) + Cl(g) \rightarrow HCl\,(s)$

D $H(g) + Cl(g) \rightarrow HCl\,(g)$

11 The enthalpy change of neutralisation between 1 mole of HC*l* and 1 mole of NaOH is given below.

$$NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l) \qquad \Delta H = -57.3 \text{ kJ mol}^{-1}$$

The enthalpy change of neutralisation between 1 mole of CH_3COOH and 1 mole of NaOH is less than −57 kJ mol^{-1}.

$$NaOH(aq) + CH_3CO_2H\,(aq) \rightarrow CH_3CO_2^{-}Na^{+}(aq) + H_2O(l) \qquad \Delta H = -54.7 \text{ kJ mol}^{-1}$$

Which statement best explains the difference between these two values?

A Heat is lost to the surroundings.

B The reaction between NaOH and CH_3CO_2H is incomplete.

C Dissociation of CH_3CO_2H is endothermic.

D CH_3CO_2H can form hydrogen bonds with water but not HC*l*.

12 Which indicator is suitable for use in a titration of 0.1 mol dm^{-3} H_2SO_4 with 0.1 mol dm^{-3} of NH_3?

A Methyl Orange (pH range 3.3 – 4.4)

B Bromothymol blue (pH range 6.0 – 7.6)

C Phenolphthalein (pH range 8.3 – 10.0)

D None of the above

13 Which mixtures, when mixed at equal volumes, would result in a buffer solution?

A 0.10 mol dm^{-3} CH_3CO_2Na and 0.05 mol dm^{-3} HC*l*

B 0.05 mol dm^{-3} CH_3CO_2H and 0.10 mol dm^{-3} NaOH

C 0.05 mol dm^{-3} CH_3CO_2H and 0.05 mol dm^{-3} NaC*l*

D 0.10 mol dm^{-3} HC*l* and 0.10 mol dm^{-3} NaOH

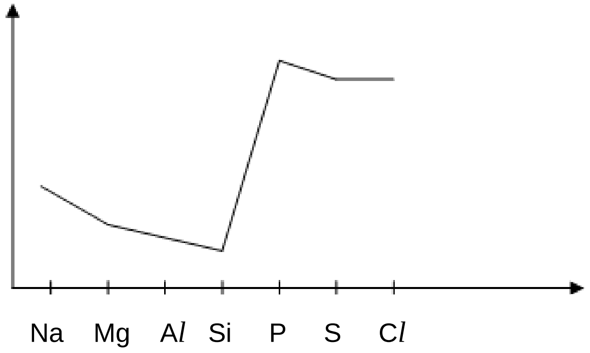
14 A theoretical reaction involves **X** + **Y** → **Z**

The rate equation is rate = $k[\mathbf{X}]^p[\mathbf{Y}]^q$ and the units of the rate constant, k, are $(\text{mol dm}^{-3})^r\ \text{min}^{-1}$.

Which set of the values of p, q and r fits the above information?

	P	*q*	*r*
A	2	0	−2
B	2	1	2
C	1	0	0
D	1	1	1

15 What property of Period 3 is shown by the graph below?



A Melting point

B Ionic radius

C Electrical conductivity

D pH of chlorides

16 Xenon is the final product formed by a series of changes in the radioactive decay of iodine 131. This radioactive decay is a *first-order reaction* with a half-life of 8 days.

What is the time period required for an iodine sample which was originally xenon free, to have a molar proportion of Iodine to Xenon in a 1:7?

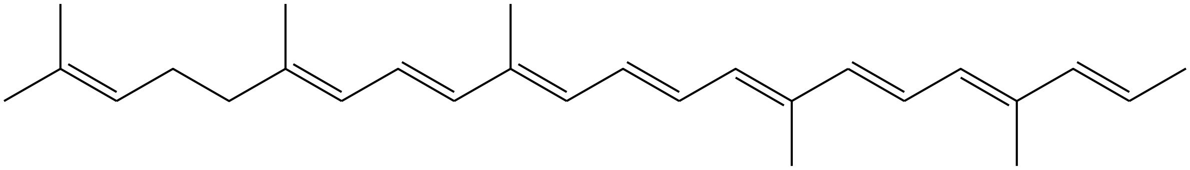
A 8 days

B 16 days

C 24 days

D 32 days

17 Determine the number of geometric isomers in the compound below:



A 2^6

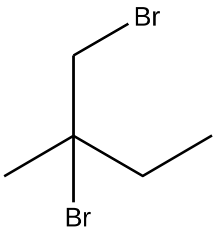
B 2^7

C 2^8

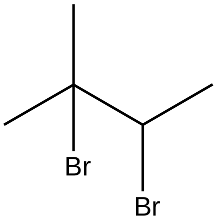
D 2^9

18 Which compound **could not** be formed by the action of bromine on an alkene of molecular formula C_5H_{10}?

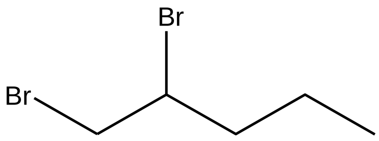
A



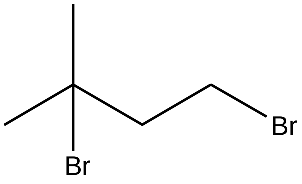
C



B



D



19 What is the structural formula of the alkene that undergoes mild oxidation to give a diol and further oxidation to give a diketone?

A $(C_2H_5)_2C{=}C(CH_3)_2$

B $CH_3CH{=}CHCH_3$

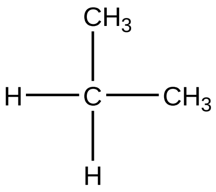
C $C_2H_5CH{=}C(CH_3)_2$

D $(CH_3)_2C{=}CHC_2H_5$

20 An alkane **Z** is reacted with chlorine gas in the presence of ultraviolet light to form two monochlorinated alkanes in an approximate molar ratio of 3 : 1.

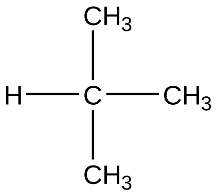
Which of the following is a possible structure for **Z**?

A



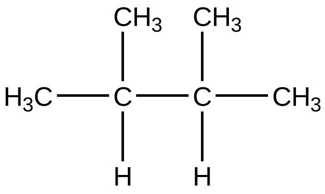
$H-\overset{CH_3}{\underset{H}{C}}-CH_3$

C



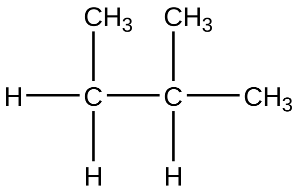
$H-\overset{CH_3}{\underset{CH_3}{C}}-CH_3$

B



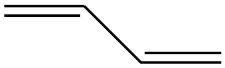
$H_3C-\overset{CH_3}{\underset{H}{C}}-\overset{CH_3}{\underset{H}{C}}-CH_3$

D



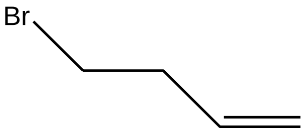
$H-\overset{CH_3}{\underset{H}{C}}-\overset{CH_3}{\underset{H}{C}}-CH_3$

21 What is the major product formed when 1 mole of buta-1,3-diene reacts with 1 mole HBr(g)?

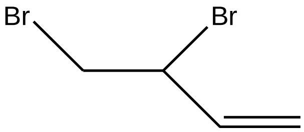


buta-1,3-diene

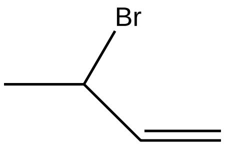
A



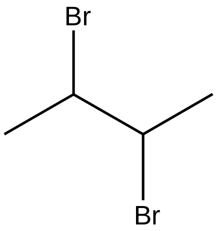
C



B



D



22 How many structural isomers of alcohol with the molecular formula, $C_4H_{10}O$, have?

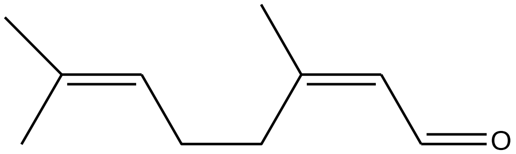
A 1

B 2

C 3

D 4

23 Which of the following is not a final product of the vigorous oxidation of citral?



citral

A CO_2

B CH_3COCH_3

C $CH_3COCH_2CH_2CO_2H$

D $(CO_2H)_2$

24 A company wants to create a perfume with an ester that has the formula. $C_2H_5CO_2CH(CH_3)_2$. In which of the following will the substances react together to produce this ester?

A C_2H_5OH and $(CH_3)_2CHCOOH$

B CH_3COOH and $CH_3CH(OH)CH_2CH_3$

C C_2H_5COOH and $(CH_3)_2CHOH$

D C_2H_5COOH and $C_2H_5CH_2OH$

25 A sample of propanal is treated with HCN in the presence of NaCN. The organic product is then refluxed with $LiAlH_4$ in dry ether.

What will be the final product?

A $CH_3CH_2CH(OH)CH_2NH_2$

B $CH_3CH_2CH(OH)CO_2H$

C $CH_3CH_2CH(OH)CONH_2$

D $CH_3CH_2COCO_2H$

Section B

For each of the questions in this section, one or more of the three numbered statements **1** to **3** may be correct. Decide whether each of the statements is or is not correct (you may find it helpful to put a tick against the statements that you consider to be correct.)

The responses **A** to **D** should be selected on the basis of

A	**B**	**C**	**D**
1,**2**, and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

No other combination of statements is used as a correct response.

26 For which pairs does species **I** have a smaller bond angle than species **II**?

	Species **I**	Species **II**
1	H_2S	SO_2
2	CO_2	CH_4
3	NH_4^+	NH_3

27 In microwave ovens, the wave energy is absorbed by polar molecules.

Which molecules would absorb microwave energy?

1 CH_3Cl

2 CH_3CO_2H

3 SO_3

28 Which reactions **can** represent standard enthalpy changes at 298 K?

1 $2C(s) + 3H_2(g) \rightarrow C_2H_6(g)$

2 $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$

3 $Ca(s) + C(s) + \frac{3}{2}O_2(g) \rightarrow CaCO_3(s)$

A	**B**	**C**	**D**
1,**2**, and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

No other combination of statements is used as a correct response.

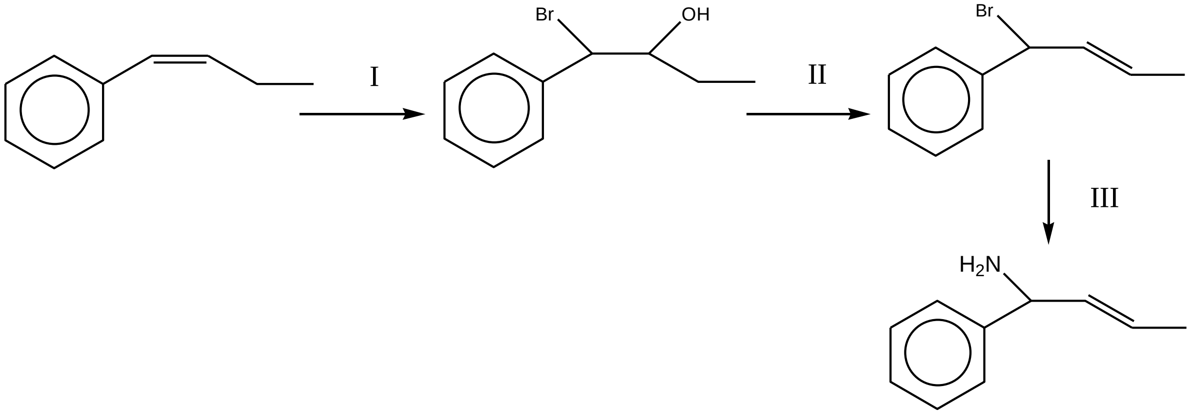
29 Which compounds yields only a single product upon heating with concentrated H_2SO_4?

1 $CH_3CH_2CH_2CH_2OH$

2 $CH_3C(OH)(CH_3)_2$

3 $CH_3CH_2CH(OH)CH_3$

30 Which types of reactions are involved in the reaction scheme below?



1 Addition

2 Substitution

3 Elimination

2017 NJC H1 Chemistry Prelim Paper 1 Suggested Answers

1	B	**6**	C	**11**	C	**16**	C	**21**	B	**26**	D
2	B	**7**	D	**12**	A	**17**	C	**22**	D	**27**	B
3	A	**8**	A	**13**	A	**18**	D	**23**	D	**28**	A
4	C	**9**	B	**14**	C	**19**	B	**24**	C	**29**	B
5	D	**10**	D	**15**	B	**20**	A	**25**	A	**30**	A

1 Amount of methane = $\frac{5}{24000}$

Hence, number of molecules = $\frac{5}{24000} \times 6.02 \times 10^{23}$

Ans: B

2 The two ions contain the same number of protons and electrons, but different number of neutrons. The electronic configuration of Fe^{2+} is $1s^2 2s^2 2p^6 3s^2 3p^6 3d^6$. (Electrons are removed from 4s orbital first when forming cations.)

The angle of deflection by an ion in an electric field is inversely proportionate to its charge to mass ratio.

E.g the larger the charge to mass ratio, the greater the deflection.

${}^{54}_{26}\mathrm{Fe}^{2+}$ ion has a smaller charge to size ratio than ${}^{56}_{26}\mathrm{Fe}^{2+}$. Hence, ${}^{54}_{26}\mathrm{Fe}^{2+}$ will be deflected more.

Ans: B

3 2nd contraction of 40 cm^3 is due to that of CO_2 reacting with the NaOH.

For the first contraction,

initial total vol = 110 cm^3 of hydrocarbon + O_2

final total vol after cooling back to rtp = 40cm^3 of CO_2 + unreacted O_2

110 – (unreacted O_2 + 40) = 30

Vol of unreacted O_2 = 40 cm^3

	C_xH_y (g)	+ $(x+\frac{y}{4})$ O_2 (g)	→	x CO_2 (g)	+ $\frac{y}{2}$ H_2O (l)
Initial vol / cm^3	10	100		0	-
Final vol / cm^3	0	40		40	-
Vol reacted/ produced/ cm^3	10	60		40	
Reacting mol ratio	1	6		4	

Comparing the mol ratio, x =4,

$x+\frac{y}{4} = 6$, y = 8

Hence, the formula of the hydrocarbon = C_4H_8

Ans: A

4 Making reference to the I.E. values from Data Booklet, we can conclude that **I** is potassium.

Element **C** is A*l*, it is in Group 13.

Element **F** is S and it exists as S_8 molecules. The lowest boiling point is Ar gas (element **H**).

Ion of **E** (P^{3-}, 0.212 nm) is larger than that of **J** (Ca^{2+}, 0.099nm)

Element **D** and **G** are Si and C*l* respectively. The compound formed is $SiCl_4$.

Ans: **C**

5 Given that both **X** and **Y** form ionic compounds with Ca, both are non-metals and are group 16.

For X to form **X**F_6 molecule while **Y** is unable to do so, that means that **X** has energetically accessible vacant d orbitals to expand beyond octet configuration while **Y** does not.

Ans: D

6 **A** $K_c = \frac{[CH_3COOCH_2CH_3][H_2O]}{[CH_3CH_2OH][CH_3COOH]}$ = no units

B $K_c = \frac{[NH_4^+][OH^-]}{[NH_3]}$ = mol dm^{-3}

C $K_c = \frac{[NH_3]}{[N_2][H_2]^3}$ = mol^{-2}dm^6

D $K_c = \frac{[Cr_2O_7^{2-}]}{[CrO_4^{2-}]^2[H^+]^2}$ = mol^{-3}dm^9

Ans: C

7 $CH_3C(CH_3)_2NH_2$ has the lowest boiling point among all the other molecules. All the molecules has 1 NH_2 group, which means they all have the same degree of hydrogen bonding between the molecules. Hence, the difference lies in the temporary dipole – induced dipole (td−id), where the $CH_3C(CH_3)_2NH_2$ is the most branched with least surface area of contact between molecules and experiences the weakest td−id among all the molecules.

Ans: D

8 **A** Refers to the enthalpy change of atomisation which is endothermic

B The neutralisation reaction between OH^- and H^+ to give H_2O is exothermic

C The formation of bonds between 2 Cl to give Cl_2 is exothermic

D Enthalpy change combustion is always exothermic

Ans: A

9 The reaction is a 2 step reaction, hence the reaction pathway must reflect 2 activation energy. Also, the overall enthalpy change is negative, which means the energy level of the product must be lower than the reactants.

Ans: B

10 Given Bond dissociation energy of H–C*l* is +432 kJ mol^{-1}

A Energy is taken in to change the state of HC*l* from (s) to (g) and then to break the H–C*l* bond. Hence energy change is more than + 432 kJ mol^{-1}

B Energy is taken in to to break the H–C*l* bond. Hence energy change is + 432 kJ mol^{-1}

C Energy is given off to form the H–C*l* bond and to change the state of HC*l* from (g) to (s). Hence energy change is less than − 432 kJ mol^{-1}

D Energy is given off to form the H–C*l* bond. Hence energy change is = − 432 kJ mol^{-1}

11 A weak acid dissociates partially in water according to the following equation:

$CH_3CO_2H \rightleftharpoons CH_3CO_2^- + H^+$

Some of the heat from the enthalpy change of neutralisation between H^+ and OH^- is compensated towards the dissociation for CH_3CO_2H. Hence less energy is released from the neutralisation reaction involving a weak acid and strong base.

Note that acid base reaction always go to completion.

Ans: C

12 Titration of a strong acid (H_2SO_4) with a weak base (NH_3). Equivalent point pH is less than 7 as NH_4^+ is a weakly acidic cation.

Methyl orange will be a suitable indicator as the working pH range of methyl orange coincides with the region of sharp pH change at equivalent point of this titration.

Ans: A

13 A buffer consists of a weak base and its conjugate acid, or a weak acid and its conjugate base.The conjugate acid-base pair differs from each other by one H^+.

A HC*l* is the limiting reagent, final solution mixture contains unreacted CH_3CO_2Na and CH_3CO_2H. They are conjugate acid-base pair and forms a buffer solution.

B CH_3CO_2H is the limiting reagent, final solution mixture contains unreacted NaOH and CH_3COO^-. This is not a buffer solution.

C No reaction between the two compounds. This is not a buffer solution.

D Both reactants react completely. Only NaC*l* is present in the solution. Not a buffer solution.

Ans: A

14 Substitute the values inside and see which one fits.

Ans: C

Units for rate = mol $dm^{-3}min^{-1}$

When p =1,q = 0, rate = k[**X**]

Units for rate constant, k = $\frac{\text{mol dm}^{-3}\text{min}^{-1}}{\text{mol dm}^{-3}}$ = min^{-1}. Hence r = 0.

15 **A** Melting point increases from Na to Si before decreasing to the non-metals.

B Ionic radius decreases from Na^+ to Si^{4+} and increases to the non-metals anions. (Check Data Booklet)

C Electrical conductivity increases from Na to A*l* and then decreases for Si and conductivity drop to zero for the non-metals.

D pH of chlorides decreases from Na to Si and remains low for the chlorides of non-metals.

Ans: B

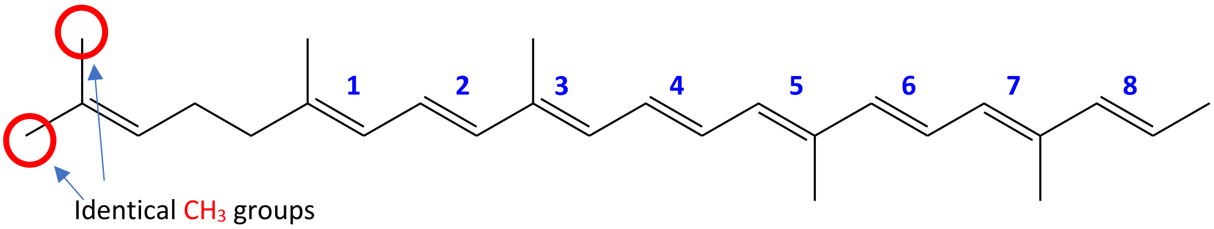
16 Radioactive decay of iodine is a first-order reaction with half-life, $t_{½}$ = 8 days

$$\begin{array}{ccccccc} \text{I : Xe} & \xrightarrow{1^{st}\ t_{½}} & \text{I : Xe} & \xrightarrow{2^{nd}\ t_{½}} & \text{I : Xe} & \xrightarrow{3^{rd}\ t_{½}} & \text{I : Xe} \\ 1 : 0 & & ½ : ½ & & ¼ : ¾ & & {}^{1}/_{8}\ \ {}^{7}/_{8} \end{array}$$

Time period = 3 × $t_{½}$ = 3 × 8 = 24 days

Ans: C

17 The <u>two conditions</u> required for geometric isomerism to exist:
(i) <u>restricted rotation</u> about a bond by the presence of a double bond (usually C=C bonds)
(ii) <u>two different groups</u> on **each of the carbon atoms** with restricted rotation.



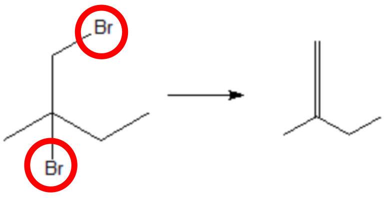
No. of geometric isomers: $\mathbf{2^{n}} = \mathbf{2^{8}}$

Ans: C

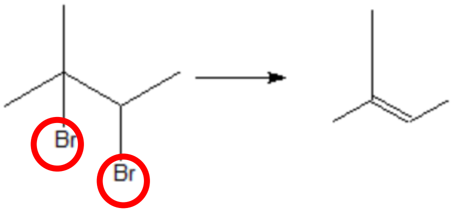
18 During the ***addition*** reaction, two Br atoms are added across the C=C bond when Br_2 reacts with alkene.

To obtain the alkene from the addition product, remove two Br atoms (circled) and reform the C=C as shown below.

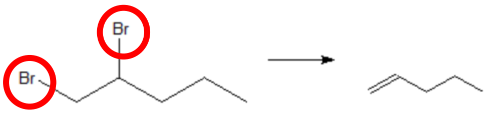
A



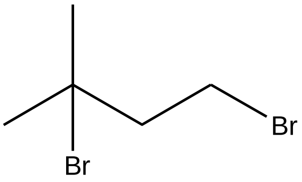
C



B

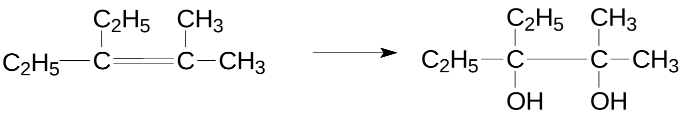


D



Ans: D

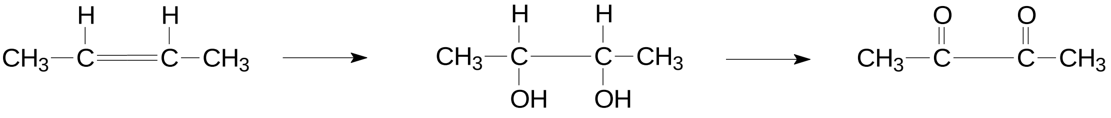
19 **A**



$$C_2H_5-\overset{\overset{C_2H_5}{|}}{C}=\overset{\overset{CH_3}{|}}{C}-CH_3 \longrightarrow C_2H_5-\underset{\underset{OH}{|}}{\overset{\overset{C_2H_5}{|}}{C}}-\underset{\underset{OH}{|}}{\overset{\overset{CH_3}{|}}{C}}-CH_3$$

(3°) (3°) (No further oxidation for 3° alcohol)

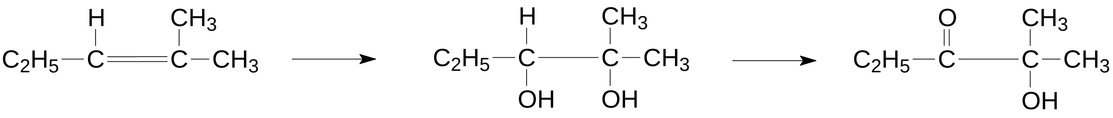
B



$$CH_3-\overset{\overset{H}{|}}{C}=\overset{\overset{H}{|}}{C}-CH_3 \longrightarrow CH_3-\underset{\underset{OH}{|}}{\overset{\overset{H}{|}}{C}}-\underset{\underset{OH}{|}}{\overset{\overset{H}{|}}{C}}-CH_3 \longrightarrow CH_3-\overset{\overset{O}{\|}}{C}-\overset{\overset{O}{\|}}{C}-CH_3$$

(2°) (2°) (diketone)

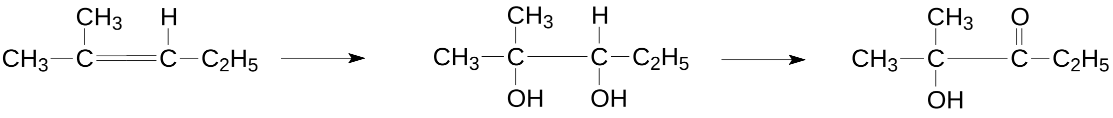
C



$$C_2H_5-\overset{\overset{H}{|}}{C}=\overset{\overset{CH_3}{|}}{C}-CH_3 \longrightarrow C_2H_5-\underset{\underset{OH}{|}}{\overset{\overset{H}{|}}{C}}-\underset{\underset{OH}{|}}{\overset{\overset{CH_3}{|}}{C}}-CH_3 \longrightarrow C_2H_5-\overset{\overset{O}{\|}}{C}-\underset{\underset{OH}{|}}{\overset{\overset{CH_3}{|}}{C}}-CH_3$$

(2°) (3°)

D

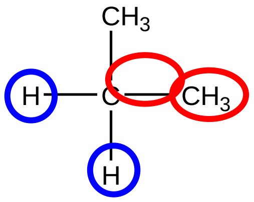


$$CH_3-\overset{\overset{CH_3}{|}}{C}=\overset{\overset{H}{|}}{C}-C_2H_5 \longrightarrow CH_3-\underset{\underset{OH}{|}}{\overset{\overset{CH_3}{|}}{C}}-\underset{\underset{OH}{|}}{\overset{\overset{H}{|}}{C}}-C_2H_5 \longrightarrow CH_3-\underset{\underset{OH}{|}}{\overset{\overset{CH_3}{|}}{C}}-\overset{\overset{O}{\|}}{C}-C_2H_5$$

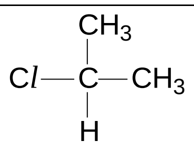
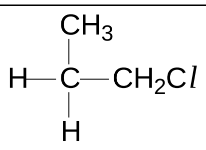
(3°) (2°)

Ans: B

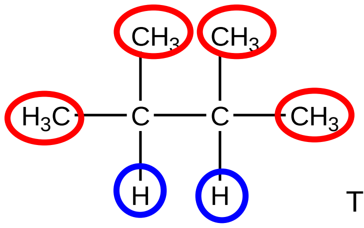
20 **A**



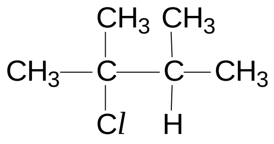
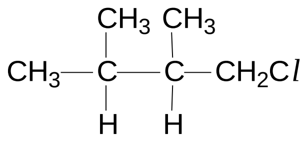
Two different types of H in the ratio of 2 : 6 (1 : 3)

Product	 $Cl—\underset{H}{\overset{CH_3}{C}}—CH_3$	 $H—\underset{H}{\overset{CH_3}{C}}—CH_2Cl$
Probability of forming	2	6

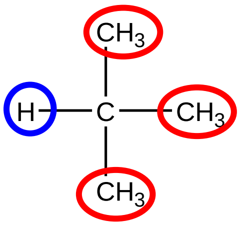
B



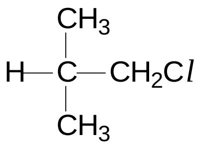
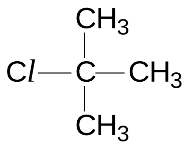
Two different types of H in the ratio of 2 :12 (1 : 6)

Product	 $CH_3—\underset{Cl}{\overset{CH_3}{C}}—\underset{H}{\overset{CH_3}{C}}—CH_3$	 $CH_3—\underset{H}{\overset{CH_3}{C}}—\underset{H}{\overset{CH_3}{C}}—CH_2Cl$
Probability of forming	2	12

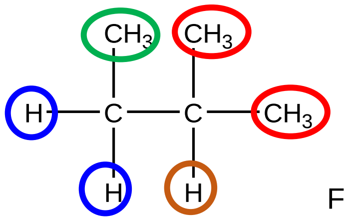
C



Two different types of H in the ratio of 1 : 9

Product	 $H—\underset{CH_3}{\overset{CH_3}{C}}—CH_2Cl$	 $Cl—\underset{CH_3}{\overset{CH_3}{C}}—CH_3$
Probability of forming	9	1

D

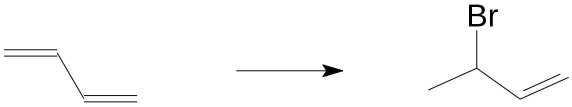


Four different types of H in the ratio of 2 : 3 : 1 : 6

Ans: A

21 During the addition of **H-X** to an alkene, the electrophile, hydrogen atom, is added to the carbon with the greater number of hydrogen atoms while the halogen atom is added to the carbon with the fewer number of hydrogen atoms to obtain the major product.

Since there are two C=C bonds in one buta-1,3-diene molecule, when 1 molecule of HBr is added, only 1 Br atom will be added to one of the two C=C bonds.

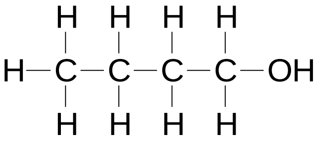


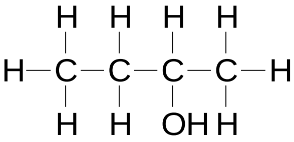
buta-1,3-diene

Ans: B

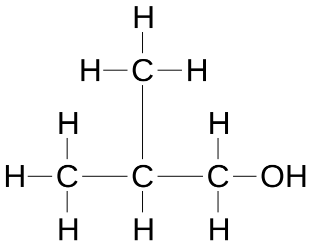
22 No. of structural isomers of alcohol with the molecular formula, $C_4H_{10}O$ = 4

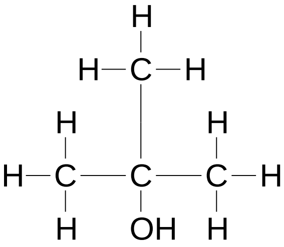
For 4 carbon chain:





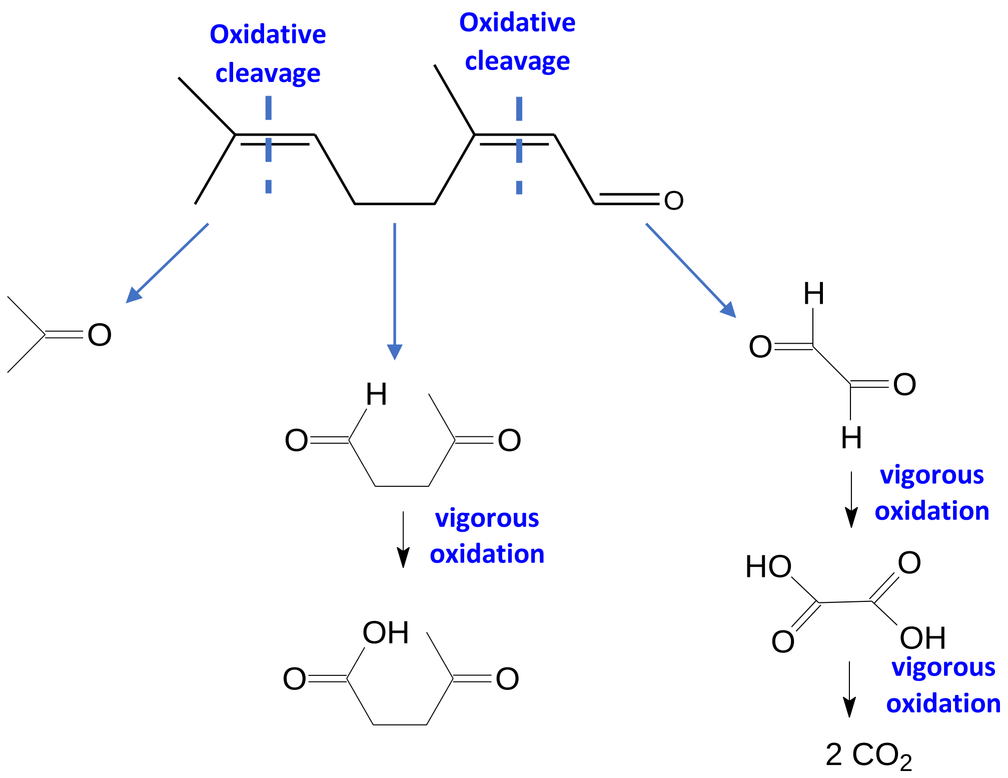
For 3 carbon chain





Ans: D

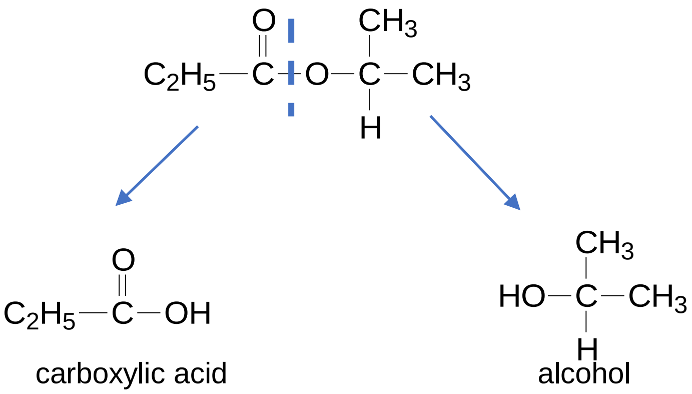
23



Therefore, $(CO_2H)_2$ is not the final product.

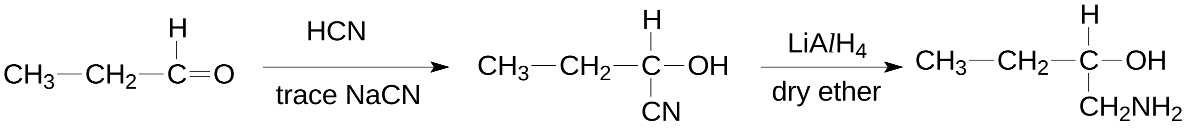
Ans: D

24 Ester has the formula. $C_2H_5CO_2CH(CH_3)_2$ with the following structure:



Ans: C

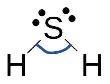
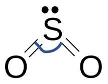
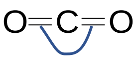
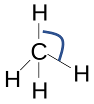
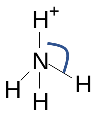
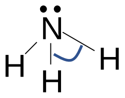
25



final product

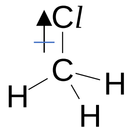
Ans: A

26

	Species **I**	Species **II**
1	H_2S  (107°)	SO_2  (118°)
2	CO_2  (180°)	CH_4  (109.5°)
3	NH_4^+  (109.5°)	NH_3  (107°)

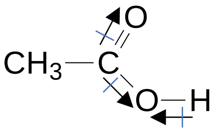
Ans: D (Option 1 only)

27 **1** CH_3Cl



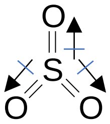
Net dipole moment (polar)

2 CH_3CO_2H



Net dipole moment (polar): dipole moments do not cancel out completely.

3 SO_3



No net dipole moment (Non-polar): dipole moments cancel out completely

Ans: B (Option 1 and 2 only)

28 **1** Standard enthalpy changes of formation of ethane

$2C(s) + 3H_2(g) \rightarrow C_2H_6(g)$

Standard enthalpy changes of formation is defined as the heat absorbed or evolved when one mole of a substance is formed from its constituent elements in their standard states at 298 K and 1 bar.

2 Standard enthalpy changes of combustion of methane

$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$

Standard enthalpy changes of combustion is defined as the heat evolved when one mole of a substance is completely burnt in excess oxygen at 298 K and 1 bar.

3 Standard enthalpy changes of formation of calcium carbonate

$Ca(s) + C(s) + \frac{3}{2}O_2(g) \rightarrow CaCO_3(s)$

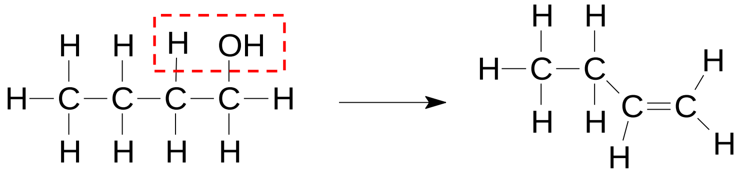
Standard enthalpy changes of formation is defined as the heat absorbed or evolved when one mole of a substance is formed from its constituent elements in their standard states at 298 K and 1 bar.

Ans: A (Option 1, 2 and 3)

29 Concentrated H_2SO_4 is a common reagent used for elimination reaction (elimination of H_2O).

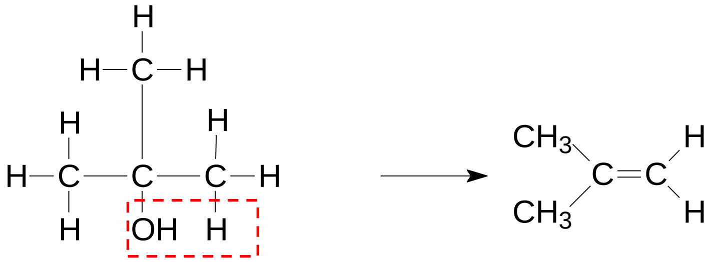
During the elimination reaction, OH and the H on the adjacent carbon atom is removed to form an alkene.

1 $CH_3CH_2CH_2CH_2OH$



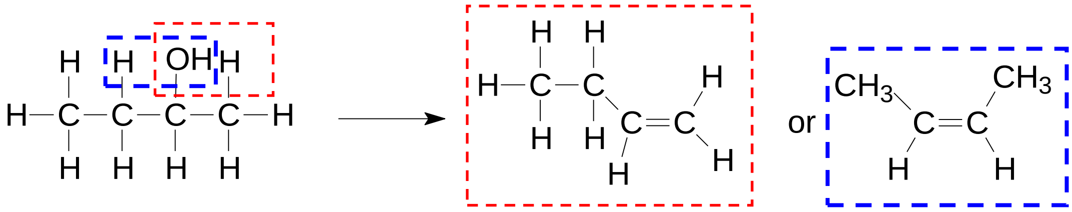
In this asymmetrical molecule, there is only one adjacent carbon atom next to the carbon atom with the OH group. Hence, there is only 1 product formed.

2 $CH_3C(OH)(CH_3)_2$



In this symmetrical molecule, there are three adjacent carbon atoms next to the carbon atom with the OH group. Hence, there is only 1 product formed.

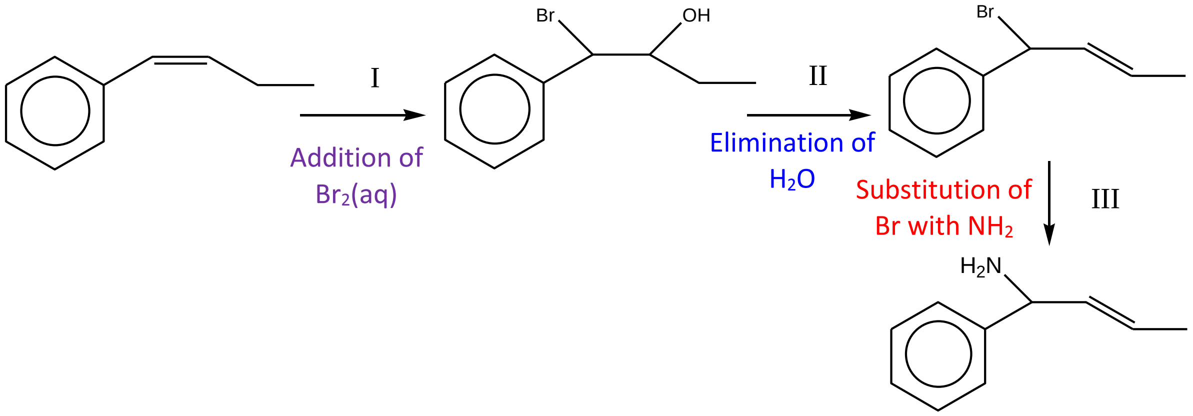
3 $CH_3CH_2CH(OH)CH_3$



In this asymmetrical molecule, there are two adjacent carbon atoms next to the carbon atom with the OH group. Hence, there are 2 products formed.

Ans: B (Option 1 and 2 only)

30



Ans: A (Option 1, 2 and 3)

NATIONAL JUNIOR COLLEGE

SH2 PRELIMINARY EXAMINATION

Higher 1

CANDIDATE NAME

SUBJECT CLASS

REGISTRATION NUMBER

CHEMISTRY

8872/02

Paper 2 Structured Questions

Thursday 24 Aug 2017
2 hours

Candidates answer **Section A** on the Question Paper.

Additional Materials: Data Booklet
Answer Paper
Graph paper (2sheets)

READ THESE INSTRUCTIONS FIRST

Write your subject class, registration number and name on all the work you hand in.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use paper clips, highlighters, glue or correction fluid/tape.

The use of an approved scientific calculator is expected, where appropriate.

Section A
Answers **all** questions.

Section B
Answers **two** questions on separate answer paper.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
1	/10
2	/7
3	/13
4	/10
5	/20
6	/20
7	/20
Paper 2	/80
Paper 1	/30
Paper 1 Percentage	/33
Paper 2 Percentage	/67
Overall Percentage	%

This document consists of **17** printed pages and **1** blank page.

Section A

Answer **all** the questions in this section in the spaces provided.

1 **(a)** Chlorine is a yellow-green gas and is the 2nd most abundant halogen after fluorine.

A mass spectrometer provides the following information about the relative abundances of the 2 isotopes.

isotope	relative abundance / %
^{35}Cl	75.76
^{37}Cl	24.24

(i) Define the term *relative isotopic mass*.

....

....

.... [1]

(ii) Using the data above, calculate the relative atomic mass of chlorine and give your answer to 4 significant figures.

[1]

(b) The table below shows the boiling points of several halogenoalkanes.

compound	boiling point / °C
1–fluorobutane	32
1–chlorobutane	78
1–bromobutane	102
1–iodobutane	127
1–chloro–2–methylpropane	68

(i) State and explain the trend in the boiling points from 1–fluorobutane to 1–iodobutane.

....

....

....

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....

....

....

....
[3]

(ii) Explain why the boiling point of 1–chloro–2–methylpropane is lower than that of 1-chlorobutane.

....

....

....

....

....
[2]

(c) Suggest a synthetic route of not more than 2 steps to form butane–1,4–dioic acid, $HO_2C–CH_2CH_2–CO_2H$, from 1,2–dibromoethane. State the reagents and conditions for each step and show the structure of the organic intermediate compound.

[3]

[Total:10]

2 **(a)** The mineral hydromagnesite is a hydrated carbonate of magnesium, with the formula $Mg_y(CO_3)_x(OH)_2.\mathbf{n}H_2O$ and a molar mass of 466 g mol^{-1}.

Hydromagnesite decomposes upon heating to form a white solid, magnesium oxide. The thermal decomposition of hydromagnesite can be expressed as follows:

$$Mg_y(CO_3)_x(OH)_2.\mathbf{n}H_2O \rightarrow \mathbf{y}MgO + \mathbf{x}CO_2 + (\mathbf{n}+1)H_2O$$

where **x**, **y** and **n** is a whole number.

(i) When 1.000 g of a pure sample of hydromagnesite is heated, it decomposes to give magnesium oxide, a white solid, till a constant mass is attained. During the decomposition, 0.378 g of carbon dioxide was given off, together with steam.

Using the above information, calculate the value of **x**.

[2]

(ii) The remaining white solid, magnesium oxide, from the above decomposition was completely dissolved in 50 cm^3 of a 1.0 mol dm^{-3} solution of hydrochloric acid and diluted to 250 cm^3.

25.0 cm^3 of the unreacted HC*l* was pipetted out from the resultant solution and required 28.50 cm^3 of a 0.10 mol dm^{-3} solution of sodium hydroxide for complete neutralisation.

I. Calculate the amount of unreacted HC*l* in 25.0 cm^3 of the resultant solution. Hence, calculate the total amount of unreacted HC*l* in 250 cm^3 of the diluted solution.

[1]

II. Calculate the total amount of HC*l* in 50.0 cm^3 of 1.0 mol dm^{-3} of hydrochloric acid. Hence, calculate the amount of HC*l* used to react with magnesium oxide.

[1]

III. Calculate the amount of magnesium oxide obtained from the decomposition of hydromagnesite and hence, calculate the value of **y**.

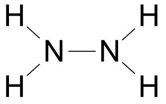
[1]

(iii) Using your answers from **a(i)**, **a(ii)** and the molar mass of hydromagnesite, deduce the value of **n** and hence, write the balanced equation for the thermal decomposition of hydromagnesite.

[2]

[Total: 7]

3 **(a)** Hydrazine, N_2H_4, is useful as a rocket fuel.



Liquid hydrazine undergoes combustion according to the following equation.

$$N_2H_4(l) + O_2(g) \rightarrow N_2(g) + 2H_2O(l)$$

(i) Define standard enthalpy change of combustion, $\Delta H_c^\ominus$, of hydrazine.

....

....

....
[1]

(ii) A student conducted an experiment to determine the standard enthalpy change of combustion of hydrazine. 0.42 g of hydrazine was ignited in excess oxygen and combusted to heat up a beaker containing 200 cm^3 of water. The temperature of water rose by 8 ^oC. The heat transfer from the combustion of hydrazine is found to be 80 % efficient.
Calculate the enthalpy change of combustion, $\Delta H_c^\ominus$, of hydrazine.

[2]

(iii) The bond energy of N≡N is found to be 945 kJ mol^{-1}.

Use the above bond energy of N≡N and the bond energy values from the *Data Booklet* to calculate the enthalpy change of combustion of hydrazine.

[2]

(iv) Suggest a reason why there is a discrepancy in the calculated value of the standard enthalpy change of combustion of hydrazine in **a(iii)** and **a(ii)**.

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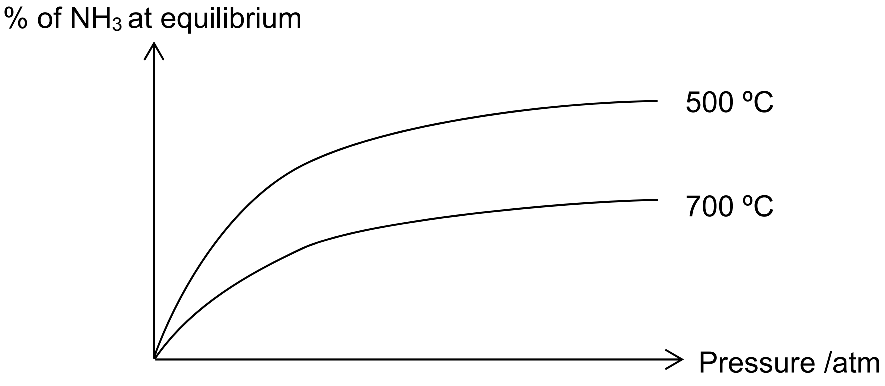
[1]

(b) In the industry, ammonia, which is used to prepare hydrazine, is synthesised by the Haber process.

$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$

(i) The figure below shows how percentage of ammonia in the equilibrium mixture varies with pressures at 500 °C and 700 °C respectively.



Use the above data to deduce whether the production of NH_3 is exothermic or endothermic process. Explain your answer.

....

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[2]

(ii) Describe and explain what would happen to the yield of NH_3 if more H_2 is added to the reaction vessel.

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[2]

(iii) In an experiment, 2 moles of nitrogen and 7 moles of hydrogen are placed in a 2 dm^3 reaction vessel initially and allowed to reach equilibrium at 573 ^{o}C. The equilibrium mixture contains 3.2 moles of NH_3. Calculate the value of equilibrium constant, K_c, at this temperature. State the units of K_c.

[3]

[Total: 13]

4 Most of earth's crust consist of solid oxides that are formed as a result of the elements being oxidised by air.

The pH of the oxides of the elements from sodium to sulfur is given in the table below:

compound	Na_2O	MgO	Al_2O_3	SiO_2	P_4O_{10}	SO_2
pH of solution	13	8	7	7	2	2
melting point / °C	1132	2852	2072	1700	24	–72

(a) Explain, in terms of structure and bonding, why MgO has a higher melting point than Na_2O.

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[3]

(b) **(i)** Suggest briefly, in terms of structure and bonding, why the pH of the solution containing SiO_2 is 7?

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[2]

(ii) A sample of silicon dioxide has been contaminated with some aluminium oxide. Describe a method which can be used to obtain a pure sample silicon dioxide. Include equations for any reactions.

....

....

....

....

[2]

(c) **(i)** Draw dot-and-cross diagram of SO_2.

[1]

(ii) Explain, with the aid of equations, the observed pH of solution when SO_2 dissolves in water.

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....

....

[2]

[Total:10]

Section B

Answer **two** questions from this section on separate answer paper.

5 **(a)** Compound **H**, $C_xH_yO_z$**,** is found to contain 62.1 % carbon and 10.3 % hydrogen by mass. The relative molecular mass, M_r, of **H** is 58.

(i) Prove that the empirical formula and molecular formula of **H** is C_3H_6O. [2]

Compound **H** does not react with sodium, but it gives orange precipitate when warmed with 2,4–dinitrophenylhydrazine.

(ii) Use your answer in **a(i)**, draw and name two structural isomers of compound **H** that satisfy the above reactions. [3]

(iii) Compound **H** does not decolourised hot acidified $KMnO_4$. Hence, write a balanced equation for the reaction between compound **H** and 2,4–dinitrophenylhydrazine and state the type of reaction. [2]

(b) Compound **M** is another isomer of compound **H** with the structural formula of $CH_2{=}CHCH_2(OH)$.

(i) How will compound **M** reacts with

(I) cold, $KMnO_4$ in dilute NaOH

(II) PCl_5

(III) ICl

In **each** case, draw the structural formula of the organic product formed.[3]

(ii) Suggest a chemical test (not repeating the above-mentioned reagents and conditions in **b(i)** that can be used to distinguish compound **M** from propan–2–ol and state the expected observation for each compound. [2]

(c) Secondary fermentation of blackberries wine converts compound **J**, $C_4H_6O_5$, to compound **K**, $C_3H_6O_3$, to decrease the acidity of the wine.

Compounds **J** and **K** undergo the following reactions.

- Both **J** and **K** react with sodium carbonate and hot acidified $K_2Cr_2O_7$, but not with 2,4–dinitrophenylhydrazine.
- Both **J** and **K** react with excess hot concentrated H_2SO_4, but only **J** gives a mixture with a pair of cis-trans isomers.
- 0.234 g sample of **J** reacts completely with 35 cm^3 of 0.10 mol dm^{-3} NaOH(aq).
- **K** give a yellow precipitate with alkaline aqueous iodine.
- 7.5×10^{-4} mol of **K** produces 18 cm^3 H_2 gas at r.t.p. when excess Na is added.

Use the information above to deduce a structure for compounds **J** and **K** and explain all the reactions involved. [8]

[Total: 20]

6 Nitrogen monoxide, NO, is a by-product of the combustion of hydrocarbon fuels in internal engines.

(a) NO is considered to be involved in the formation of ‘acid rain’. State one other undesirable consequence of the presence of NO in the atmosphere. [1]

(b) The reaction between $H_2(g)$ and NO(g) was studied.

$$2H_2(g) + 2NO(g) \rightarrow 2H_2O(g) + N_2(g)$$

The rate of reaction was measured at different times at a constant temperature and the results are shown in the table below.

$[H_2]$ / mol dm^{-3}	2.20	2.00	1.80	1.50	1.25	0.80
rate / mol dm^{-3} s^{-1}	22.7×10^{-4}	21.1×10^{-4}	18.9×10^{-4}	15.7×10^{-4}	13.1×10^{-4}	8.3×10^{-4}

(i) Plot a graph of rate against $[H_2]$. [2]

(ii) Use your graph to find the order of reaction with respect to H_2. [1]

To determine the order of reaction with respect to NO, a series of experiments using different concentration of H_2 and NO were carried out at a constant temperature. The results are shown in the table below.

experiment	initial concentration of $H_2(g)$ / mol dm^{-3}	initial concentration of NO(g) / mol dm^{-3}	initial rate / mol dm^{-3}s^{-1}
1	2.0×10^{-3}	2.0×10^{-3}	3.0×10^{-7}
2	4.0×10^{-3}	4.0×10^{-3}	2.4×10^{-6}

(iii) Use the data above, deduce the order of reaction with respect to NO. [2]

(iv) Write the rate equation for the reaction between H_2 and NO. [1]

(v) Calculate the value for the rate constant, *k*, using the data from the experiment 1 result. State the units for *k*. [3]

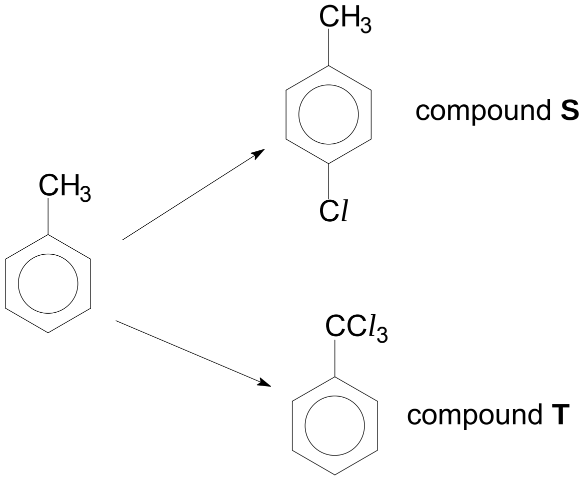
(c) Nitrogen monoxide, NO, is one of the atmospheric pollutants emitted from petrol car engines. It can be removed by passing the exhaust gases through a catalytic converter which has a platinum-rhodium mixture coated onto a fine-meshed aluminium alloy filter. The nitrogen monoxide is decomposed by excess carbon monoxide to form nitrogen and carbon dioxide.

(i) Write a balanced equation, with state symbols, to show how nitrogen monoxide is removed in the catalytic convertor. [1]

(ii) Suggest why the catalyst in the catalytic converter is in the form of a fine mesh? [1]

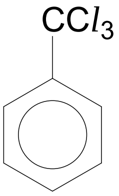
(iii) Explain why a catalyst is used in the catalytic converter with the aid of an energy distribution diagram to illustrate your answer. [3]

(d) Methylbenzene can undergo halogenation reaction with chlorine under different conditions to form two organic compounds, **S** and **T**.

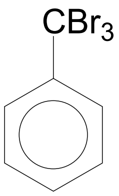


(i) State the reagents and conditions for the formation of compounds **S** and **T**. [2]

(ii) Using your knowledge of the halogenoalkanes, arrange in increasing order of reactivity for the hydrolysis of the following three compounds. [1]



I



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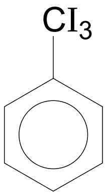


III

(iii) Hence, explain the difference in the reactivity for the above three compounds. [2]

[Total: 20]

7 **(a)** **(i)** Sketch a graph to show the variation in the first ionisation energy of the elements across Period 3 from Na to C*l*. [2]

(ii) Suggest explanation for the observed variation in the first ionisation energy of the elements across Period 3. [3]

Chloroethane can be formed from the reaction between ethane and chlorine. When chloroethane undergoes hydrolysis with sodium hydroxide, hydrogen chloride is produced and dissolves in water to form hydrochloric acid, which reacts with excess sodium hydroxide present in the solution.

(iii) State the type of reaction that has occurred between hydrochloric acid and sodium hydroxide and write a balanced equation. [2]

(iv) Hence, calculate the standard enthalpy change of reaction between hydrochloric acid and sodium hydroxide given the following enthalpies:

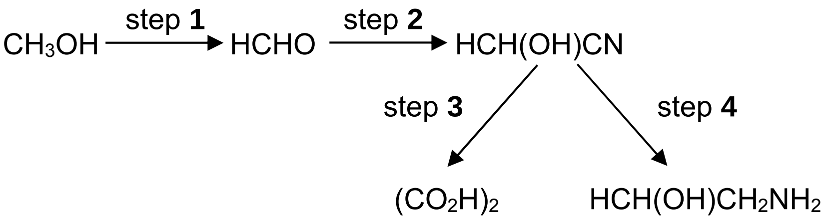
compound	$\Delta H^{\ominus}_{f}$ / kJ mol^{-1}
NaOH(aq)	–469.15
NaC*l*(aq)	–407.27
HC*l*(aq)	–167.20
H_2O(*l*)	–285.83

[2]

(v) Using your answer in **a(iv)**, suggest a value for the enthalpy change of neutralisation, $\Delta H^{\ominus}_{neu}$, of the reaction when barium hydroxide, $Ba(OH)_2$, which acts as a strong base, is reacted with hydrochloric acid instead. [1]

(b) **(i)** Calculate the oxidation number of carbon in methanol, CH_3OH. [1]

(ii) Methanol can undergo the following reaction scheme.



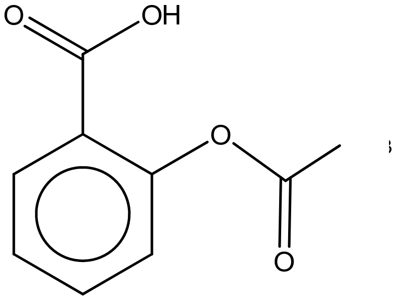
State the reagent and conditions for steps **1**, **2**, **3** and **4**. [4]

(c) In human body, carbon dioxide, that is produced, will dissolve in water present in the blood to form a carbonic acid–hydrogen carbonate (H_2CO_3/HCO_3^-) buffer system.

(i) Explain, with the aid of equations, how the buffer system helps to control and maintain the pH in the blood. [2]

(ii) Although the blood has a pH value of 7.4, the pH in the stomach is 2.5. Calculate the hydrogen ion concentration, [H⁺], present in the stomach. [1]

(d) Aspirin is also known as acetylsalicylic acid and the structure of aspirin is as shown below.



Draw the organic products formed when aspirin reacts with HC*l* (aq) in the presence of heat. [2]

[Total: 20]

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2017 NJC H1 Chemistry Prelim Paper 2 Suggested Answers

1 **(a)** **(i)** The mass of an isotope of an element relative to $^{1}/_{12}$ the mass of one atom of ^{12}C.

(ii) relative atomic mass of chlorine
= (75.76/100) × 35 + (24.24/100) × 37
= 35.48 (4s.f.)

(b) **(i)** The boiling point **increases** from as 1–fluorobutane to 1–iodobutane. The halogenoalkanes are made up of **simple covalent molecules** held by **temporary dipole-induced dipole interactions**. There is an increase in M_r from 1–fluorobutane to 1–iodobutane and hence the **electron cloud size increases**, making it **more easily polarised** and leading to **increasingly stronger** temporary dipole induced dipole interactions. Hence, **more energy** is needed to overcome the increasingly stronger temporary dipole induced dipole interactions between the halogenoalkanes, leading to the increase in boiling point from 1–fluorobutane to 1–iodobutane.

(ii) Both are **simple covalent compounds** with **temporary dipole – induced dipole interactions**. 1-chloro–2-methylpropane is **branched while 1–bromobutane is a straight chain**. Thus, there is **greater surface of contact** between the 1–bromobutane molecules than 1–chloro–2–methylpropane, leading to **greater temporary dipole - induced dipole** interactions between 1–bromobutane that requires **more energy** to overcome.

(c)

$$BrCH_2CH_2Br \xrightarrow[\text{heat}]{\text{ethanol, NaCN}} NCCH_2CH_2CN \xrightarrow[\text{heat}]{H_2SO_4(aq)} HO_2CCH_2CH_2CO_2H$$

2 **(a)** **(i)** Amount of hydromagnesite = 1/466 = 2.146 × 10^{-3} mol

Amount of CO_2 given off = 0.378/44.0 = 8.591 × 10^{-3} mol

Mole ratio of hydromagnesite: CO_2 = 2.146 × 10^{-3} : 8.591 × 10^{-3}
= 1 : 4
x = 4

(ii) I
$NaOH + HCl \rightarrow NaCl + H_2O$

Amount of NaOH used to neutralise remaining HC*l* in 25 cm^3
= (28.50/1000) x 0.10
= 2.85 x 10^{-3} mol

Amt of remaining HC*l* in 250 cm^3 = (2.85 x 10^{-3}) x (250/25.0)
= 0.02850 mol

II

Amount of HC*l* used in 50 cm^3 of HC*l* solution
= (50/1000) x 1.0
= 0.05000 mol

Amt of HC*l* reacted with MgO
= 0.05000 – 0.02850
= 0.02150 mol

III

$MgO + 2HCl \rightarrow MgCl_2 + H_2O$

Amt of MgO formed = 0.02150/2 = 0.0107 mol

Mole ratio of hydromagnesite: MgO = 2.146×10^{-3} : 0.0107
= 1 : 5

y = 5

(iii) Molar mass of hdromagnesite = 466 g mol^{-1}

$Mg_5(CO_3)_4(OH)_2.\mathbf{n}H_2O$

Mass of water per mole of hdromagnesite
= 466 – [(5 x 24.3) + (4 x 12.0) + (14 x 16.0) + 2(1.0)]
= 70.5 g

n = 70.5/18.0 = 3.917 ≈ 4

Balanced equation: $Mg_5(CO_3)_4(OH)_2.4H_2O \rightarrow 5MgO + 4CO_2 + 5H_2O$

3 **(a)** **(i)** Standard enthalpy change of combustion of hydrazine is the heat liberated when 1 mole of hydrazine is completely burnt in excess oxygen at 298 K and 1 atm.

(ii) Amount of heat gained by water, $q = mc\Delta T$
$q = 200 \times 4.18 \times 8$
= 6688 J

Amount of heat evolved, $q = 6688 \times (100/80)$
= 8360 J

Amount of hydrazine = 0.42/32 = 0.01313 mol

$\Delta H_c^{\ominus}$(hydrazine) = $-q/n_{hydrazine}$
= –8360/0.01313
= – 637000
= – 637 kJ mol^{-1}

(iii)

bonds broken	bond energy/ kJ mol^{-1}	bonds formed	bond energy/ kJ mol^{-1}
1 N–N	+160	1 N≡N	–945
4 N–H	4(+390)	4 O–H	4(–460)
1 O=O	+496		

$$\begin{aligned}\Delta H^{\ominus}_{c}\text{(hydrazine)} &= \text{BE(Bonds broken)} + \text{BE(Bonds formed)}\\ &= [160 + 4(390) + 496] + [(-945) + 4(-460)]\\ &= -\,569\ \text{kJ mol}^{-1}\end{aligned}$$

(iv) The bond energy values obtained from the Data booklet are average values which would differ from the actual bond energy in the molecule due to the different chemical environment. Therefore, there would be discrepancy in the calculated value.

Or

The bond energy values obtained from the Data booklet are used on gaseous molecules. However, in the balanced equation of combustion of hydrazine, both hydrazine and water are in liquid state and not in gaseous state. Therefore, there would be discrepancy in the calculated value.

(b) **(i)** The production of NH_3 is an exothermic reaction since at lower temperature, there is a higher percentage of NH_3 at equilibrium, implying that the forward exothermic reaction is favoured to counteract the decrease in temperature.

(ii) When more H_2 is added to the reaction vessel, by **Le Chatelier's principle**, position of **equilibrium shifts right** to **partially remove the increased concentration of H_2**, resulting in a **greater yield of NH_3.**

(iii)

$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$

	N_2	$3H_2$	$2NH_3$
Initial amount / mol	2	7	0
Change / mol	–x	–3x	+2x
Equilibrium amount / mol	2–(1.6) =0.4	7–3(1.6) =2.2	3.2
Equilibrium concentration / mol dm^{-3}	0.4/2 =0.2	2.2/2 = 1.1	3.2/2 = 1.6

$2x = 3.2$

$x = 1.6$

$$K_c = \frac{[NH_3]^2}{[N_2][H_2]^3}$$

$$= \frac{[1.6]^2}{[0.2]1.1]^3}$$

$K_c = 9.617$

$= 9.62\ mol^{-2}\ dm^{6}$

4 **(a)** Both MgO and Na_2O have giant ionic lattice structure with strong ionic bonds between the oppositely charged ions. Both compounds contain the same O^{2-} ion, but Mg^{2+} ion has a higher charge and smaller ionic radius than Na^+ ion. Since $|L.E.| \propto \frac{q^+q^-}{r^+ + r^-}$, MgO, therefore, has a higher magnitude of lattice energy than that of Na_2O and hence more energy is needed to overcome the stronger ionic bond in MgO than in Na_2O. Thus, MgO has higher melting point than Na_2O.

(b) **(i)** SiO_2 has a giant covalent lattice structure with covalent bonding between Si and O atoms. The covalent bond in SiO_2 are too strong to overcome. Hence, SiO_2 are insoluble in water.

(ii) $Al_2O_3 + 6H^+ \rightarrow 2Al^{3+} + 3H_2O$

Add hot HC*l*(aq) to the contaminated mixture to remove the Al_2O_3. Filter the mixture and keep the residue which contains the SiO_2.

(c) **(i)**

(ii) $SO_2 + H_2O \rightarrow H_2SO_3$

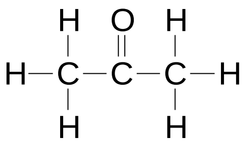
$H_2SO_3 \rightleftharpoons HSO_3^- + H^+$

5 **(a)** **(i)**

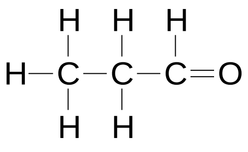
	C	H	O
Composition by mass	62.1	10.3	27.6
Divide by A_r	62.1/12 = 5.175	10.3/1 =10.3	27.6/16 =1.725
Divide by smallest number	5.175/1.725 =3	10.3/1.725 =6	1.725/1.725 =1
Simplest mole ratio	3	6	1

Molecular formula of **H** = Empirical formula of **H** = C_3H_6O (M_r = 58)

(ii)

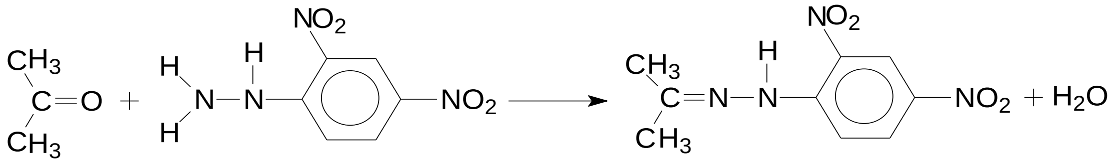


propanone



propanal

(iii)



Condensation

(b) **(i)** I: $CH_2(OH)CH(OH)CH_2(OH)$

II: $CH_2{=}CHCH_2Cl$

III: $CH_2(I)CH(Cl)CH_2(OH)$

(ii) *Test:* Add Br_2(aq) or Br_2 in CCl_4
Observation:
M: Decolourisation of orange Br_2(aq)/ reddish-brown Br_2 in CCl_4
propan–2–ol: orange Br_2(aq)/ reddish-brown Br_2 in CCl_4 remains.

OR

Test: $KMnO_4$, dilute H_2SO_4, heat
Observation:
M: Decolourisation of purple $KMnO_4$ and effervescence.
propan–2–ol: Decolourisation of purple $KMnO_4$.

OR

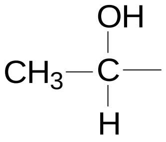
Test: cold, NaOH(aq), $KMnO_4$
Observation:
M: Decolourisation of purple $KMnO_4$, brown ppt of MnO_2 formed.
propan–2–ol: No decolourisation of purple $KMnO_4$/ Purple solution remains.

OR

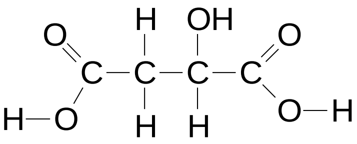
Test: I_2(aq), NaOH(aq), warm
Observation:
M: No yellow ppt of CHI_3
propan–2–ol: Yellow ppt of CHI_3 is formed.

(c)

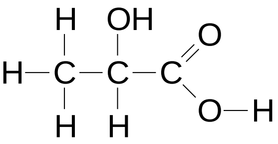
Information	Deduction
Both **J** and **K** react with sodium hydroxide	**J** and **K** undergoes acid base reaction with sodium hydroxide. ➔ Both compounds contain COOH group.
Both **J** and **K** react with acidified $K_2Cr_2O_7$, but not with 2,4–dinitrophenylhydrazine reagent.	**J** and **K** undergoes oxidation reaction with $K_2Cr_2O_7$. ➔ Both compounds are not carbonyl compound and contain OH group.

Both **J** and **K** react with excess hot concentrated H_2SO_4, but only **J** gives a mixture with a pair of cis-trans isomers.	**J** and **K** undergoes elimination of H_2O to form alkene. Alkenes obtained from **J** exhibited cis-trans isomerism, but not that of **K** (terminal alkene).
A 0.234 g sample of **J** reacts completely with 35 cm^3 of 0.10 mol dm^{-3} NaOH.	J undergoes neutralisation/acid base reaction with NaOH. Amt of **J**= $\frac{0.234}{134}$ =1.746 x10^{-3} mol Amt of NaOH = 3.5 x 10^{-3} mol Mole ratio of **J**: NaOH is 1:2 **J** is dibasic acid which contains two COOH groups.
K give a yellow precipitate with alkaline aqueous iodine.	**K** undergoes mild oxidation with alkaline aqueous iodine. **K** contains the following structure  $CH_3-\overset{OH}{\underset{H}{C}}-$
A 7.5 x 10^{-4} mol of **K** produces 18 cm^3 H_2 gas when excess Na is added.	**K** undergoes redox/ acid metal reaction with Na. Amt of H_2 liberated = 18/24000 =7.5 x 10^{-4} mol Mole ratio of **K**:H_2 is 1:1 **K** contains two OH groups (make up of 1 COOH and 1 OH group).

J:

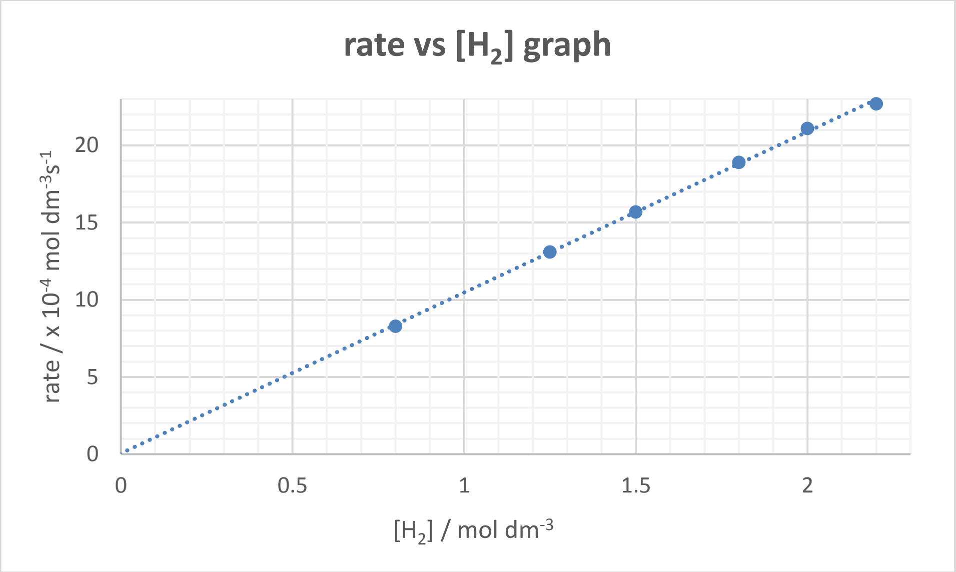


K:



6 **(a)** NO is one of the pollutants which causes photochemical smog. Such smog causes respiratory problems.

(b) **(i)**



Correct axes label with appropriate units and appropriate scale
Correct plotting of points and the graph must occupy at least half of the grid paper.

(ii) Since the graph is a straight line graph with constant gradient, this implies that the rate is directly proportional to [H$_2$], therefore it is 1st order reaction w.r.t H$_2$.

(iii)

$$\frac{\text{rate}_{\text{expt1}}}{\text{rate}_{\text{expt2}}} = \frac{[\text{H}_2]_{\text{expt1}}[\text{NO}]^{n}_{\text{expt1}}}{[\text{H}_2]_{\text{expt2}}[\text{NO}]^{n}_{\text{expt2}}}$$

$$\frac{3.0\times10^{-7}}{2.4\times10^{-6}} = \frac{(2.0\times10^{-3})(2.0\times10^{-3})^{n}}{(4.0\times10^{-3})(4.0\times10^{-3})^{n}}$$

$$\frac{3.0\times10^{-7}}{2.4\times10^{-6}} = \frac{(2.0\times10^{-3})}{(4.0\times10^{-3})}\left(\frac{2.0\times10^{-3}}{4.0\times10^{-3}}\right)^{n}$$

$n = 2$
Order of reaction w.r.t NO is 2.

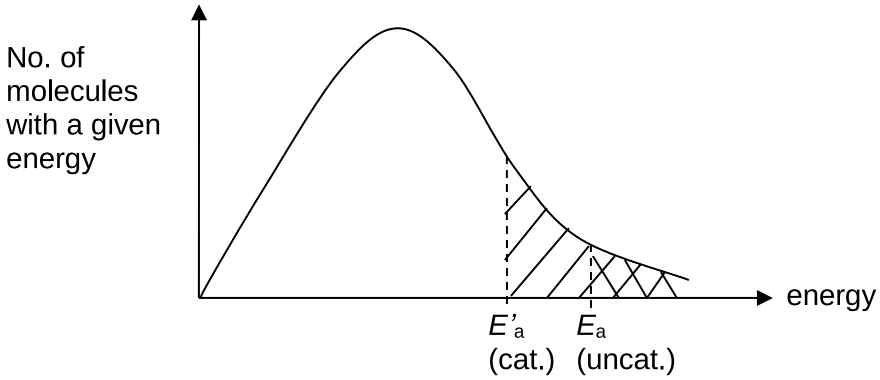
(iv) rate = k[NO]^2[H$_2$]

(v) k = rate/[NO]^2[H$_2$]
= (3.0 x 10^{-7})/ (2.0 x 10^{-3})^3
= 37.5 mol^{-2} dm^6 s^{-1}

(c) **(i)** $2NO(g) + 2CO(g) \rightarrow N_2(g) + 2CO_2(g)$

(ii) The fine mesh is used so as to maximise the surface area on which the catalytic reaction takes place.

(iii)



Correct axes label, graph start from origin, labels and shading for E_a for each catalysed and un catalysted reaction.

In the presence of a catalyst, the reaction proceeds via an alternative reaction pathway with a lower activation energy.

Hence, frequency of effective collisions increases as more reactant molecules possess sufficient energy to overcome the lowered activation energy, E_a' (shown by the greater shaded area under the curve) and rate of reaction increases.

(d) **(i)** Compound **S**: Cl_2 and anhydrous $AlCl_3$

Compound **T**: excess $Cl_2(g)$ and UV light or high temperature

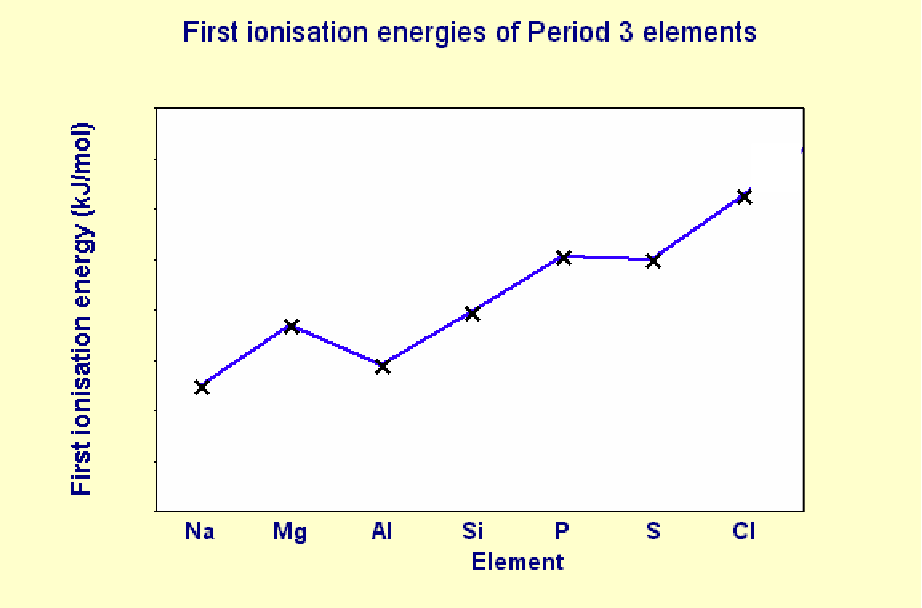
(ii) Reactivity: **I** < **II**< **III**

(iii) During hydrolysis, the C–X (where X = C*l*, Br & I) bond needs to be broken. Down the group, the atomic radius of the halogens increases from C*l* to I and hence the C–X bond length increases from C–C*l* to C– I. Thus, the C-X bond strength decreases down the group resulting in increasing ease of hydrolysis from C–C*l* to C– I.

Or

Quote the bond energy for C–X from Data booklet
BE(C–C*l*) = 340 kJ mol^{-1}
BE (C–Br) = 280 kJ mol^{-1}
BE (C–I) = 240 kJ mol^{-1}
Thus, the C-X bond strength decreases down the group resulting in increasing ease of hydrolysis from C–C*l* to C– I.

7 **(a)** **(i)**



(ii) There is a general increase in 1st ionization energy from Na to C*l*. Across the period, as the number of proton increases, **nuclear charge increases**. However, the number of inner core electrons remain the same, thus **shielding effect remains relatively constant**. Therefore, increasing ionisation energy is needed to remove the most loosely held electron from the increasing nuclear attraction.

There are two anomalies in 1st ionisation energy between.

(i) **Mg vs A*l***

The most loosely held electron in A*l* is in the 3p orbital while the most loosely held electron in Mg is in the 3s orbital. **The 3p orbital is further away (at a higher energy level) from the nucleus than the 3s orbital. This outweighs the increase in nuclear charge,** resulting in a **weaker nuclear attraction for the most loosely held electron** and thus requires less energy to remove it, giving A*l* a lower first ionisation energy

(ii) **P vs S**

The most loosely held electron from S is from the paired electrons in 3p orbital whereas that of P comes from the singly filled 3p orbital. The **inter-electronic repulsion between the paired electrons in the same orbital outweighs the effect of increasing nuclear charge**, resulting in **weaker nuclear attraction for the *most loosely held electron***. Less energy is thus needed to remove it, giving S a lower first ionisation energy

(iii) Acid-base reaction/ Neutralisation

$NaOH + HCl \rightarrow NaCl + H_2O$

(iv) $\Delta H^{\ominus}_{rxn} = [\Delta H^{\ominus}_f(NaCl) + \Delta H^{\ominus}_f(H_2O)] - [\Delta H^{\ominus}_f(HCl) + \Delta H^{\ominus}_f(NaOH)]$

$= [(-407.27) + (-285.83)] - [(-167.20)+(-469.15)]$

$= -56.75$

$= -56.8 \text{ kJ mol}^{-1}$

(v) ΔH^{e}_{neu}= –56.8 kJ mol^{-1} as $Ba(OH)_2$ is a strong base.
ΔH^{e}_{neu} for strong acids + strong base reactions are the same.

(b) **(i)** –2

(ii) step **1**: $K_2Cr_2O_7$, H_2SO_4(aq), heat with immediate distillation

step **2**: HCN, trace amount of NaCN or NaOH, cold

step **3**: $K_2Cr_2O_7$, H_2SO_4(aq), heat

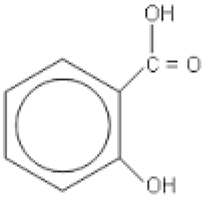
step **4**: LiA*l*H_4 in dry ether/ H_2, Pt / H_2, Ni, heat

(c) **(i)** Addition of H^+: $HCO_3^- + H^+ \rightarrow H_2CO_3$
Addition of OH^-: $H_2CO_3 + OH^- \rightarrow HCO_3^- + H_2O$
When small amount of H^+ or OH^- is added, the large reservoir of HCO_3^- and H_2CO_3 will neutralise H^+ and OH^- respectively. Hence pH is maintained.

(ii) pH = – log [H^+]

[H^+] = $10^{-2.5}$
= 3.162 x 10^{-3}
= 3.16 x 10^{-3} mol dm^{-3} (3 s.f.)

(d)



CH_3COOH