CANDIDATE'S NAME: ________________________________ CTG: ____________

YISHUN JUNIOR COLLEGE

2017 JC2 PRELIMINARY EXAMINATION

CHEMISTRY **8872/01**

HIGHER 1

Paper 1 Multiple Choice Questions

FRIDAY 15 SEPTEMBER 2017

0800hrs − 0850hrs

(50 minutes)

Additional Materials: Optical Mark Sheet (OMS)
Data Booklet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Write your name, CTG, and NRIC / FIN number on the Optical Mark Sheet (OMS), and shade the corresponding boxes for your NRIC / FIN number.

There are **thirty** 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.

Section A

For each question there are four possible answers, **A**, **B**, **C**, and **D**. Choose the **one** you consider to be correct and shade your choice on the answer sheet provided.

1 Calcium nitrate, $Ca(NO_3)_2$, is added to fireworks to give a red colouration. When ignited, it reacts with carbon to produce calcium oxide, CaO, and three gases; CO_2, CO and Z. The three gases are produced in a mole ratio of 2 : 1 : 1 respectively.

What is gas Z?

A N_2 **B** N_2O **C** NO **D** NO_2

2 Naturally occurring silicon is a mixture of three isotopes, ^{28}Si, ^{29}Si and ^{30}Si. The relative atomic mass of silicon is 28.109.

What could be the relative abundance of each of the three isotopes?

A 91.1% ^{28}Si; 7.9% ^{29}Si; 1.0% ^{30}Si

B 92.2% ^{28}Si; 4.7% ^{29}Si; 3.1% ^{30}Si

C 95.0% ^{28}Si; 3.2% ^{29}Si; 1.8% ^{30}Si

D 96.3% ^{28}Si; 0.3% ^{29}Si; 3.4% ^{30}Si

3 The reaction of hydrogen sulfide and sulfur dioxide gives sulfur as one of the products.

$$H_2S(aq) \rightleftharpoons S(s) + 2H^+(aq) + 2e^-$$

$$SO_2(aq) + 4H^+ + 4e^- \rightleftharpoons S(s) + 2H_2O(l)$$

How many moles of hydrogen sulfide are needed to react with sulfur dioxide to produce 1 mole of sulfur?

A 2 mol **B** $\frac{3}{2}$ mol **C** 1 mol **D** $\frac{2}{3}$ mol

4 *Use of Data Booklet is relevant to this question.*

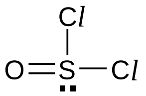
In research on the atomic nucleus, scientists have been comparing the stability of isotopes with the same neutron : proton ratio.

Which isotope has the same neutron : proton ratio as ^{10}B?

A ^{40}Ar **B** ^{40}K **C** ^{32}P **D** ^{32}S

5 Thionyl chloride, $SOCl_2$, can be used to convert alcohols into chloroalkanes.

Thionyl chloride can be represented as



What value does Valence Shell Electron Pair Repulsion theory suggest for the bond angle in thioyl chloride?

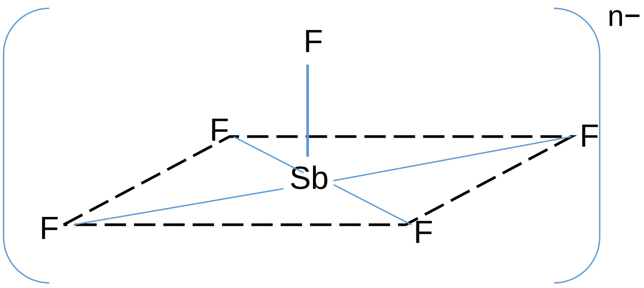
A 90° exactly

B 107° approximately

C 118° approximately

D 120° exactly

6 Antimony, Sb, is in Group 15 of the Periodic Table. It forms a series of salts which contain the SbF_5^{n-} anion, the structure of which is a square-based pyramid.



Deduce the value of n.

A 1 **B** 2 **C** 3 **D** 4

7 Pressurising butane in a cylinder causes it to liquify. It is then sold as 'liquidfied petroleum gas', LPG. Under the same conditions, methane remains as a gas.

Which best explains why butane is more easily liquified than methane?

A Its molecule contains more electrons than that of methane.

B Its molecue contains more atoms than that of methane.

C Its molecular mass is higher than that of methane.

D Its molecule has a dipole moment, whereas methane does not.

8 Which row of the table is correct?

	least exothermic lattice energy	$\longrightarrow$	most exothermic lattice energy
A	sodium sulfide	lithium sulfide	lithium oxide
B	lithium sulfide	lithium oxide	sodium sulfide
C	lithium oxide	sodium sulfide	lithium sulfide
D	lithium oxide	lithium sulfide	sodium sulfide

9 *Use of the Data Booklet is relevant to this question.*

Trichloromethane, $CHCl_3$, commonly known as chloroform, was used as an anaesthetic in surgery. One reason for it not being used today is that it naturally oxidises to phosgene, $COCl_2$, which is highly toxic.

$$2CHCl_3 + O_2 \rightarrow 2\ O{=}\overset{\overset{Cl}{|}}{C}{-}Cl + 2HCl$$

What is the enthalpy change, ΔH, for this reaction?

A -2342 kJ mol^{-1}

B -346 kJ mol^{-1}

C $+75$ kJ mol^{-1}

D $+1996$ kJ mol^{-1}

10 The table shows the enthalpy change of neutralisation per mole of water formed, ΔH, for various acids and bases.

acid	base	ΔH / kJ mol^{-1}
hydrochloric acid	sodium hydroxide	−57.0
P	sodium hydroxide	−54.0
hydrochloric acid	Q	−52.0
nitric acid	R	−57.0

What are P, Q and R?

	P	Q	R
A	ethanoic acid	ammonia	potassium hydroxide
B	ethanoic acid	sodium hydroxide	ammonia
C	sulfuric acid	ammonia	potassium hydroxide
D	sulfuric acid	sodium hydroxide	ammonia

11 What is meant by the term *dynamic equilibrium*?

A an equilibrium that is constantly changing its position

B an equilibrium where the forward and reverse reactions are taking place at different rates

C an equilibrium where the forward and reverse reactions are taking place at the same rate

D an equilibrium which has not yet settled to a constant rate

12 Each of the following equilibria is subjected to two changes which are carried out separately.

I the pressure is reduced at constant temperature.

II the temperature is increased at constant pressure.

For which equilibrium will **both** of these changes result in an increase in the proportion of products?

A $I_2(g) + H_2(g) \rightleftharpoons 2HI(g)$ $\Delta H = +53$ kJ mol^{-1}

B $N_2O_4(g) \rightleftharpoons 2NO_2(g)$ $\Delta H = +57$ kJ mol^{-1}

C $3H_2(g) + N_2(g) \rightleftharpoons 2NH_3(g)$ $\Delta H = -92$ kJ mol^{-1}

D $4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g)$ $\Delta H = -950$ kJmol^{-1}

13 Values for the ionic product of water, K_w, at two different temperatures are given below.

Temperature / °C	K_w / mol^2 dm^{-6}
25	1.00×10^{-14}
30	1.44×10^{-14}

What is correct for pure water at 30 °C?

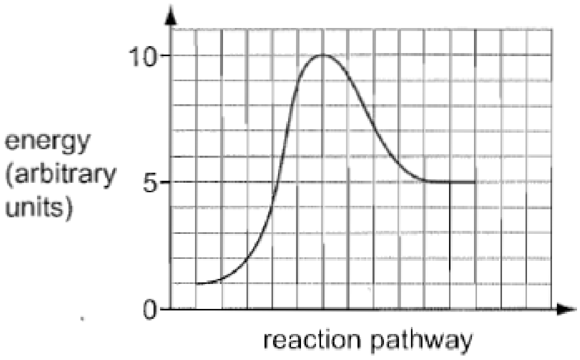
A $[H^+] > [OH^-]$

B pH = 1.44×10^{-7}

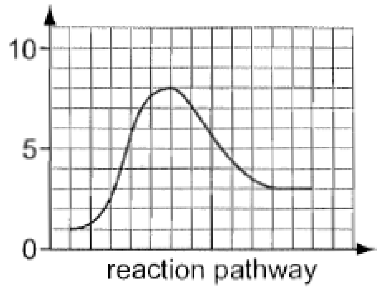
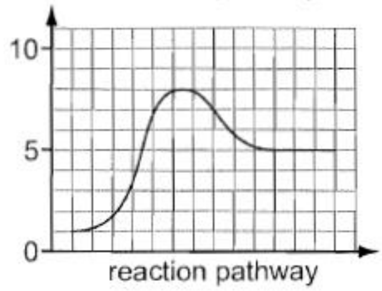
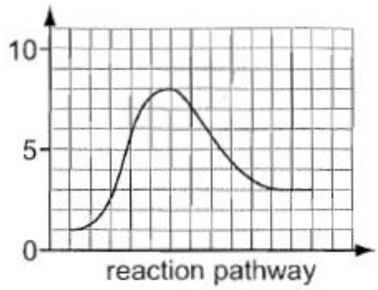
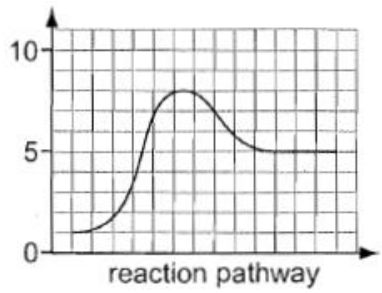
C pH < 7

D pH > 7

14 The diagram shows the reaction pathway diagram for an uncatalysed reaction.

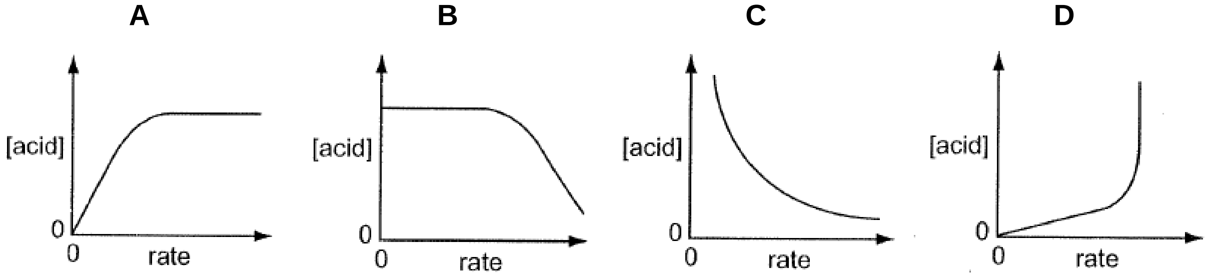


The reaction is then catalysed.
What are the changes in the rate constant and the reaction pathway diagram?

	rate constant	energy profile
A	decrease	
B	decrease	
C	increase	
D	increase	

15 In the reaction between aqueous sodium thiosulfate and dilute acid, the reaction is found to be first order with respect to acid at low concentrations of acid, but zero order with respect to acid when the acid concentration is high.

Which graph represents the experimental results?



16 The ionic radii of Na^{+}, Mg^{2+} and Al^{3+} are 0.095 nm, 0.065 nm and 0.050 nm respectively.

Which of the following statements correctly explains the decrease in radius from Na^{+} to Al^{3+}?

A an increase in the nuclear charge and total number of electrons

B an increase in the nuclear charge and constant total number of electrons

C an increase in total number of electrons while nuclear charge remains constant

D a decrease in nuclear charge while total number of electrons remains constant

17 In the preparation of silicon, silicon dioxide is heated with magnesium.

$$SiO_2 + 2Mg \rightarrow 2MgO + Si$$

The product mixture contains MgO and Si only.

To separate the silicon from the product mixture, students proposed the following two possible methods.

1. Shake the mixture with aqueous hydrochloric acid and filter.
2. Heat the mixture gently and collect the evaporated silicon.

Which methods would work?

A 1 and 2 **B** 1 only **C** 2 only **D** neither 1 or 2

18 How many esters have the molecular formula $C_4H_8O_2$?

A 2 **B** 3 **C** 4 **D** 5

19 The Russian composer Borodin was widely respected for his work as a chemist. In 1869, he discovered a reaction in which two ethanol molecules combine to form a new β-hydroxy carbonyl compound. A similar reaction is shown below.

I $2CH_3COCH_3 \rightarrow CH_3COCH_2C(OH)(CH_3)_2$

II $CH_3COCH_2C(OH)(CH_3)_2 \rightarrow CH_3COCH{=}C(CH_3)_2 + H_2O$

Which of the following best describes reactions I and II?

	I	II
A	addition	elimination
B	substitution	elimination
C	addition	reduction
D	condensation	elimination

20 Which statement about an ethene molecule is **not** correct?

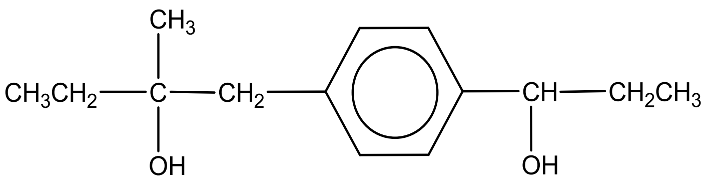
A It has all its atoms in the same plane.

B It has an empirical formula of CH_2.

C It has bond angles of 109°.

D It has five σ bonds and one π bond.

21 The compound shown below is a derivative of ibuprofen, which is a painkiller.



Which of the following reagents and conditions will react with only one alcohol group in the derivative of ibuprofen?

A anhydrous PCl_5

B concentrated H_2SO_4, 170 °C

C I_2 dissolved in NaOH (aq), warm

D $Cr_2O_7^{2-}$, H_2SO_4 (aq), heat

22 Which compound could **not** be a product of a single reaction of 2-bromobutane?

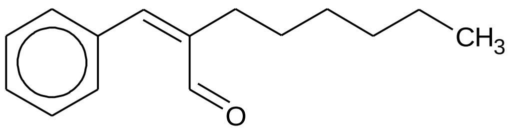
A but-1-ene

B butan-2-ol

C butane

D butyl-2-amine

23 Hexyl cinnamaldehyde is found in the essential oil of chamomile and is commonly used as a perfume.



If hexyl cinnamaldehyde is reacted with $NaBH_4$, what would be the M_r of the resultant product?

A 204 **B** 218 **C** 220 **D** 226

24 Compound X, $C_4H_6O_2$, which is responsible for giving butter its characteristic flavour, gives the following experimental observations.

- On reduction, X produces $C_4H_{10}O_2$.
- With hydrogen cyanide and aqueous sodium cyanide, X produces $C_6H_8N_2O_2$.
- On warming X with Fehling's solution, the solution remains blue.

What could be the structural formula of X?

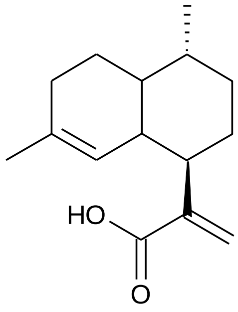
A $CH_2{=}CHCOCH_2OH$

B $CH_3COCH{=}CHOH$

C $CH_3COCOCH_3$

D CH_3COCH_2CHO

25 Artemisinic acid is a useful intermediate for making the anti-malarial drug, artemisin.



artemisinic acid

Which statement about this compound is **not** correct?

A It can exhibit geometric isomerism around a double bond.

B It can be esterified by ethanol, in the presence of H^+ ions.

C It has a molecular formula of $C_{15}H_{22}O_2$.

D It will decolourise cold, dilute MnO_4^- ions.

Section B

For each of the questions in this section, one or more of the three numbered statements **1** to **3** may be correct.

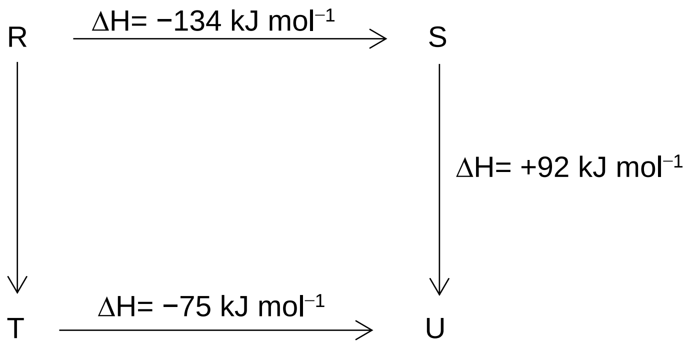
Decide whether each of the statements is or is not correct (you may find it helpful to pick a tick against the statements that you consider to be correct).

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 The diagram illustrates the energy changes for a set of reactions.



Which statements are correct?

1 The enthalpy change for the transformation R $\rightarrow$ T is +33 kJ mol^{-1}

2 The enthalpy change for the transformation T $\rightarrow$ S is endothermic.

3 S has a higher energy content than U.

27 Which statements about order of reaction are correct?

1 Only first order reactions have constant half-lives.

2 Measurements of the initial rates of reaction can be used to determine the overall order of a reaction.

3 The units of a rate constant are independent of the order of the reaction.

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.

28 When 0.10 mol of chloride of a Period 3 element, A, is reacted with a limited amount of water, white fumes are observed. Upon dissolving the white fumes in water, the resultant solution is found to react with 0.30 mol of aqueous sodium hydroxide.

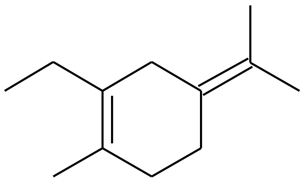
Which Groups of the Periodic Table can A belong to?

1 15

2 13

3 14

29 Compound N has the following structure.



compound N

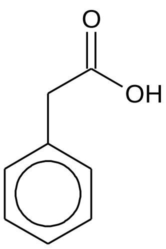
Which of the following statements are correct when compound N is treated with $KMnO_4$ in the presence of hot dilute sulfuric acid?

1 The products contain at least one carbonyl functional group.

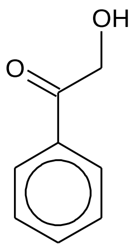
2 The products contain at least one carboxylic acid functional group.

3 There is only one organic product.

30 Which of the following reagents can be used to distinguish the following two compounds, P and Q?



P



Q

1 2,4-DNPH, warm

2 hot acidified $K_2Cr_2O_7$

3 Na_2CO_3 (aq)

~ END OF PAPER ~

Paper 1 Worked Solutions

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

1 Bearing in mind the mole ratio of the three gases when writing the balanced equation, you should be able to conclude that 1 mole of $Ca(NO_3)_2$ requires 3 moles of C:

$$Ca(NO_3)_2 + 3C \rightarrow CaO + 2CO_2 + CO + Z$$

It should also be clear that all the number of O atoms on both sides of the equation are already equal (i.e. balanced), and thus Z have to be N_2 so that the number of N atoms (the only remaining element to be balanced) on both sides are equal:

$$Ca(NO_3)_2 + 3C \rightarrow CaO + 2CO_2 + CO + \mathbf{N_2}$$

Answer: **A**

2

A: $A_r = \dfrac{91.1(28)+7.9(29)+1.0(30)}{100} = 28.099$

B: $A_r = \dfrac{92.2(28)+4.7(29)+3.1(30)}{100} = 28.109$

C: $A_r = \dfrac{95.0(28)+3.2(29)+1.8(30)}{100} = 28.068$

D: $A_r = \dfrac{96.3(28)+0.3(29)+3.4(30)}{100} = 28.071$

Answer: **B**

3 To get the balanced equation:

$$\begin{array}{l} H_2S(aq) \rightarrow S(s) + 2H^+(aq) + 2e^- \ (\times 2) \\ \underline{SO_2(aq) + 4H^+ + 4e^- \rightarrow S(s) + 2H_2O(l)} \\ 2H_2S(aq) + SO_2(aq) \rightarrow 3S(s) + 2H_2O(l) \end{array}$$

Dividing throughout by 3, we get:

$$\frac{2}{3} H_2S(aq) + \frac{1}{3} SO_2(aq) \rightarrow S(s) + \frac{2}{3} H_2O(l)$$

Answer: **D**

4 For ^{10}B: number of protons = 5;
number of neutrons = 10 − 5 = 5
⇒ ratio of proton : neutron = 1 : 1

A: ^{40}Ar: number of protons = 18;
number of neutrons = 40 − 18 = 22
⇒ ratio of proton : neutron = 9 : 11

B: ^{40}K: number of protons = 19;
number of neutrons = 40 − 19 = 21
⇒ ratio of proton : neutron = 19 : 21

C: ^{32}P: number of protons = 15;
number of neutrons = 32 − 15 = 17
⇒ ratio of proton : neutron = 15 : 17

D: ^{32}S: number of protons = 16;
number of neutrons = 32 − 16 = 16
⇒ ratio of proton : neutron = 1 : 1

Answer: **D**

5 Around the S-atom, there are 3 bond pairs and 1 lone pair of electrons (a double bond is considered one bond pair).
By VSEPR theory, the four electron pairs will space themselves as far apart as possible to minimise repulsion, leading to an electronic geometry of tetrahedral, and a bond angle of 109°. However, as the lone pair-bond pair repulsion are stronger than bond pair-bond pair repulsion, the bond angle will be smaller than 109°, ⇒ approximately 107°.

Answer: **B**

6 In order for the anion to have a square pyramidal shape, it must have 5 bond pairs and 1 lone pair of electrons. Since Sb is from group 15, it has 5 valence electrons, which are used to form normal single bond with the five F-atoms (i.e. 5 bond pairs). Hence Sb must receive **two electrons** from external sources, in order to have one lone pairs of electrons.
⇒ n = 2, i.e. the anion is SnF_5^{2-}.

Answer: **B**

7 Since both butane and methane are made up of non-polar molecules, only id-id interactions exist between their respective molecules. As butane has more electrons than methane, its electron cloud is more polarisable, and so the instantaneous dipole-induced dipole interactions between its molecules are stronger, and hence it is easier to liquify butane than methane.

Answer: **A**

8 $L.E. = \left| \dfrac{q_+ \times q_-}{r_+ + r_-} \right|$

Cationic radii: $Li^+ < Na^+$
Anionic radii: $O^{2-} < S^{2-}$
sodium sulfide, Na_2S, has the least exothermic lattice energy while lithium oxide, Li_2O, has the most exothermic lattice energy.

Answer: **A**

9 Bond breaking: 2(C−H) +6(C−C*l*) + (O=O)
= 2(+410)+6(+340)+(+496)
= +3356 kJ mol^{-1}
Bond forming: 2(C=O) +4(C−C*l*) + 2(H−C*l*)
=2(−740)+4(−340)+2(−431)
=−3702 kJ mol^{-1}
ΔH = (+3356) + (−3702) = −346 kJ mol^{-1}

Answer: **B**

10 For the first pair of acid and base, we learnt that ΔH for a strong acid (HC*l*) and a strong base (NaOH) is −57.0 kJ mol^{-1}.

Since the magnitude of ΔH for the second pair of acid and base is smaller than 57.0 kJ mol^{-1}, a weak acid must have reacted with NaOH.
⇒ P must be ethanoic acid (option **A** or **B**).

Since the magnitude of ΔH for the third pair of acid and base is smaller than 57.0 kJ mol^{-1}, HC*l* must have reacted with a weak base.
⇒ Q must be ammonia (option **A** or **C**).

Since ΔH for the fourth pair of acid and base is also − 57.0 kJ mol^{-1}, nitric acid must have reacted with a strong base.
⇒ R must be potassium hydroxide (option **A** or **C**).

Answer: **A**

11 Definition of a dynamic equilibrium: an equilibrium where the forward and reverse reactions are continuing at the **same rate** (or that the forward and reverse reaction are taking place, but the rate is not equals to zero).

Answer: **C**

12 When pressure is reduced at constant temperature, equilibrium position will shift to the side with a larger number of moles of gases to increase pressure (option **B** or **D**).

When temperature is increased, the endothermic reaction will occur to a greater extent to absorb heat (option **A** or **B**)

Answer: **B**

13 $K_w = [H^+]\,[OH^-]$ (by definition)

At 30 °C, $K_w = 1.44 \times 10^{-14}$ mol^2 dm^{-6}
⇒ $[H^+]\,[OH^-] = 1.44 \times 10^{-14}$

Since $[H^+] = [OH^-]$ for pure water,
⇒ $[H^+]^2 = 1.44 \times 10^{-14}$
⇒ $[H^+] = 1.2 \times 10^{-7}$

pH = $-\log [H^+] = -\log (1.2 \times 10^{-7}) = 6.92$ (< 7)

Answer: **C**

14 Catalyst increases the rate constant (options **C** and **D**).

Catalyst lowers the activation energy (all four options).

Catalyst does not alter the energy level of the reactants and the products (options **B** and **D**).

Answer: **D**

15 When [acid] is low, reaction is first order with respect to acid
⇒ rate increases linearly as [acid] increases (options **A** or **D**).

When [acid] is high, reaction is zero order with respect to acid.
⇒ rate remains the same as [acid] increases i.e. the graph approaches a verticlal line (option **D**).

Answer: **D**

16 Number of protons increases from Na^+ to Al^{3+}, and hence nuclear charge increases.

Na^+, Mg^{2+} and Al^{3+} have the same total number of electrons.

As a result, the effective nuclear charge (net electrostatic force of attraction between the nucleus and valence electrons) increases from Na^+ to Al^{3+}, and so ionic radii decreases.

Answer: **B**

17 Since MgO will react with and dissolve in HC*l* (as a soluble salt is formed):

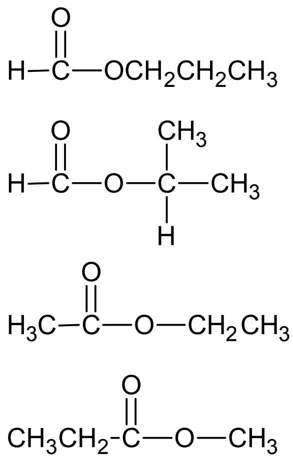
$$MgO + 2HCl \rightarrow MgCl_2 + H_2O$$

and Si will not react with or dissolve in HC*l*. Hence Si can be removed from the solution by filtration. ⇒ Method 1 will work (option **A** or **B**).

Since both MgO and Si have very high melting and boiling points, neither of them will vapourise on gentle heating.
⇒ Method 2 will **not** work (option **B** or **D**).

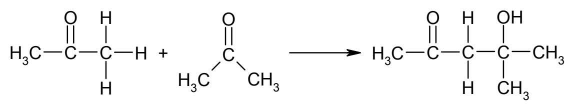
Answer: **B**

18 The four possible isomers with molecular formula $C_4H_8O_2$ are:

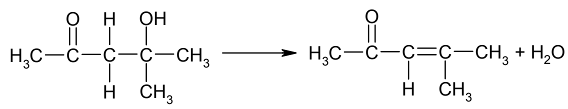


Answer: **C**

19 I is an <u>addition</u> reaction as the first propanone molecule is added across the C=O double bond of the second propanone molecule to produce an alcohol:



II is an <u>elimination</u> reaction as an unsaturated alkene is formed with the elimination of a water molecule from the alcohol:



Answer: **A**

20 **A**: Correct. Since there are 3 bond pair and 0 lone pair of electrons around each of the two C-atoms, the shape around each C-atom is trigonal planar. Hence all two C-atoms and four H-atoms lie on the same plane.

B: Correct. Molecular formula of ethane is C_2H_4, and so the empirical formula (showing the lowest mole ratio) is CH_2.

C: Not correct. As the shape around each C-atom is trigonal planar, the bond angle is 120°.

D: Correct. Each of the two C-atoms forms one σ-bond with two H-atoms (total of four σ-bonds), and there is one σ-bond and one π-bond between the two C-atoms.

Answer: **C**

21 **A**: Incorrect. Both alcohol groups can undergo substitution with PCl_5.

B: Incorrect. Both alcohol groups can undergo elimination of water.

C: Incorrect. Neither alcohols contain the $-CH(OH)CH_3$ group.

D: Correct. Only one of the alcohol is a secondary alcohol and can be oxidised by $Cr_2O_7^{2-}$; the other is a tertiary alcohol and cannot be oxidised.

Answer: **D**

22 **A**: Incorrect. But-1-ene can be formed from 2-bromobutane by the elimination of HBr using hot ethanolic KOH.

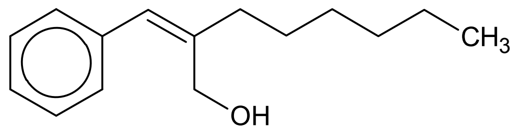
B: Incorrect. Butan-2-ol can be formed from 2-bromobutane by (nucleophilic) substitution using hot NaOH(aq).

C: Correct. A 2-bromobutane cannot be converted to butane in one step.

D: Incorrect. Butan-2-amine can be formed from 2-bromobutane by (nucleophilic) substitution using ethanolic NH_3, heat in sealed tube.

Answer: **C**

23 Only the aldehyde can be reduced by $NaBH_4$ to form a primary alcohol. The C=C is not reduced. The product is shown below:



$C_{15}H_{22}O$

$M_r(C_{15}H_{22}O) = 218$

Answer: **B**

24 **A**: Incorrect. Although $CH_2{=}CHCOCH_2OH$ can be reduced (using H_2(g), Pt) to form $CH_3CH_2CH(OH)CH_2OH$ - $C_4H_{10}O_2$, and it does not react with Fehling's solution (as it does not contain an aldehyde group), when treated with HCN and NaCN, it will not form $C_6H_8N_2O_2$, as it only has one ketone group (it will form $CH_2{=}CHC(CN)(OH)CH_2OH$ instead).

B: Incorrect. Although $CH_3COCH{=}CHOH$ can be reduced (using H_2(g), Pt) to form $CH_3CH(OH)CH_2CH_2OH$ - $C_4H_{10}O_2$, and it does not react with Fehling's solution (as it does not contain an aldehyde group), when treated with HCN and NaCN, it will not form $C_6H_8N_2O_2$, as it only has one ketone group (it will form $CH_3C(CN)(OH)CH{=}CHOH$ instead).

C: Correct. $CH_3COCOCH_3$ can be reduced to form $CH_3CH(OH)CH(OH)CH_3$ - $C_4H_{10}O_2$, react with HCN and NaCN to form $CH_3C(CN)(OH)C(CN(OH)CH_3$ - $C_6H_8N_2O_2$, and it does not react with Fehling's solution (as it does not contain an aldehyde group)

D: Incorrect. Although CH_3COCH_2CHO can be reduced to form $CH_3CH(OH)CH_2CH_2OH$ - $C_4H_{10}O_2$, react with HCN and NaCN to form $CH_3C(CN)(OH)CH_2CH(CN)OH$ - $C_6H_8N_2O_2$, it will form a brick red ppt with Fehling's solution (as it contains an aldehyde group)

Answer: **C**

25 **A**: Incorrect. Although artemisinic acid have two C=C double bond, it is not able to exhibit geometric (cis-trans) isomerism. This is because one of the C=C is within a ring (⇒ the two carbon groups that are part of the ring, must be placed in the cis-position relative to each other), and for the other C=C, there are two H-atoms on one of the C-atom.

B: Correct. As artemisinic acid have a carboxylic acid group, it can react with ethanol to form an ester with (with conc H_2SO_4 as a catalyst).

C: Correct. Artemisinic acid have a molecular formula of $C_{15}H_{22}O_2$.

D: Correct. As artemisinic acid have two alkene functional groups, it can undergo mild oxidation with cold dilute MnO_4^- to form diols.

Answer: **A**

26 **1**: Correct: $-134 = \Delta H_{R\rightarrow T} + (-75) - (+92)$

$\Delta H_{R\rightarrow T} = (-134) + 75 + 92 = +33 \text{ kJ mol}^{-1}$

2: Incorrect. $\Delta H_{T\rightarrow S} = (-75) - (+92)$

$= -167 \text{ kJ mol}^{-1}$ (exothermic)

3: Incorrect. From **S** → **U**, 92 kJ of energy is absorbed per mole of reaction.
⇒ **U** has a higher energy content than **S**.

Answer: **D**

27 **1**: Correct statement.

2: Correct statement.

3: Incorrect. **Units of rate constant = $(\text{mol dm}^{-3})^{1-n}$ s^{-1}**
(where n= overall order of reaction)

Answer: **B**

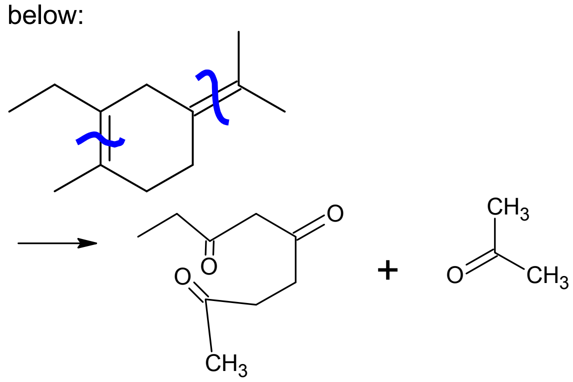
28 The chloride of element A reacts with water to form white fumes of HCl. Since HCl reacts with NaOH in a 1 : 1 ratio, 1 mole of chloride produces 3 moles of HCl.

$AlCl_3(s) + 3H_2O(l) \rightarrow Al(OH)_3(s) + 3HCl(g)$
$PCl_3(l) + 3H_2O(l) \rightarrow H_3PO_3(aq) + 3HCl(aq)$

Element A can either belong to Group 13 or 15.

Answer: **B**

29 Compound N undergoes oxidative cleavage as below:



1: Correct. Both products are ketones.

2: Incorrect. There is no carboxylic acid formed.

3: Incorrect. There are two products (and both are organic).

Answer: **D**

30 **1**: Correct. Q is a ketone and will give orange precipitate with 2,4-DNPH, while no ppt will be formed with P.

2: Correct. Q is a primary alcohol and will turn $Cr_2O_7^{2-}$ from orange to green, while $Cr_2O_7^{2-}$ will remain orange with P. (Note that $Cr_2O_7^{2-}$ is not a strong enough oxidising agent to cause side chain oxidation to occur in P).

3: Correct. P is a carboxylic acid and will give effervescence which forms white precipitate with limewater, while no effervescence will be produced with Q.

Answer: **A**

Parent's Signature:

CANDIDATE'S NAME: ______________________________ CTG: __________

YISHUN JUNIOR COLLEGE

2017 JC2 PRELIMINARY EXAMINATION

CHEMISTRY **8872/02**
HIGHER 1

Paper 2 Structured and Free Response Questions **THURSDAY 24 AUGUST 2017**
1400hrs − 1600hrs
(2 hours)

Candidates answer Section A on the Question Paper

Additional Materials: Writing Paper
Data Booklet

INSTRUCTIONS TO CANDIDATES

Write your name and CTG in the spaces at the top of this page and on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use paper clips, glue or correction fluid.

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

Section A
Answer **all** the questions

Section B
Answer **two** questions on separate writing 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	
Paper 1	
Total	**/ 30**
Paper 2	
Section A	/ 40
B5	/ 20
B6	/ 20
B7	/ 20
Total	**/ 80**
Overall	**/ 110**

Section A

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

1 Antacids can be taken to relieve symptoms of indigestion, heartburn or stomach ulcer by neutralising gastric acid, and commonly contain sodium bicarbonate, magnesium hydroxide, aluminium hydroxide or calcium carbonate. The acidity of gastric acid is contributed mainly by hydrochloric acid.

(a) Sodium bicarbonate, $NaHCO_3$, is a very quick-acting antacid, but it should only be used for temporary relief. This is because its excessive use will lead to an increase in the pH value of the gastric juices above 7, which will lead to rebound acid secretion by the cells in the lining of the stomach.

Aluminium hydroxide, $Al(OH)_3$, and calcium carbonate, $CaCO_3$, are the active ingredients in the more popular antacids available in the market.

(i) Write an equation to illustrate how aluminium hydroxide relieves acid indigestion.

.... [1]

(ii) Suggest a possible advantage of using aluminium hydroxide or calcium carbonate as an antacid compared to sodium bicarbonate.

....

.... [1]

(b) A popular brand of antacid has the following drug facts on its label.

Drug Facts

Active ingredient (in each tablet)	**Purpose**
Calcium carbonate 500 mg	Antacid

Warnings

Ask a doctor or pharmacist before use if you are now taking a prescription drug. Antacids may interact with certain prescription drugs.
When taking this product do not exceed 15 tablets daily or use the maximum dosage for more than 2 weeks.
Keep out of reach of children.

Directions chew 2 to 4 tablets as symptoms occur

Other information

- each tablet contains calcium 215 mg and magnesium 5 mg
- store at 20 °C − 25 °C

Supplementary Facts
Serving size: 2 Tablets (1.30 g per tablet), Servings: 150,
Amount Per Serving: Total Carb 1 g, Sugars 1 g, Calcium 430 mg

Calcium carbonate reacts with hydrochloric acid to produce carbon dioxide gas as shown in the following equation.

$$CaCO_3(aq) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$$

A student was given an antacid tablet and tasked to verify the mass of calcium carbonate claimed by the manufacturer on the drug facts label. She crushed five tablets with a pestle and mortar to form a powder and reacted with 100.0 cm^3, an excess, of 0.50 mol dm^{-3} hydrochloric acid. The carbon dioxide produced was collected and found to occupy 550 cm^3 at s.t.p..

(i) Calculate the number of moles of carbon dioxide produced.

number of moles of CO_2 = ... [1]

(ii) Assuming that calcium carbonate is the only ingredient in the antacid tablet that reacts with hydrochloric acid, calculate the mass of calcium carbonate reacted.

mass of calcium carbonate reacted = ... [2]

(iii) Hence, deduce whether the mass of calcium carbonate claimed by the manufacturer on the drug facts label is valid.

....

....

.... [2]

[Total: 7]

2 The Periodic Table we currently use is derived from that proposed by Mendeleev in 1869 after he had noticed patterns in the chemical properties of the elements.

Use the third period of the modern Periodic Table, sodium to chlorine, to answer the following questions.

(a) **(i)** Describe how the melting point of these elements varies across the period.

....

....

....

.... [2]

(ii) Describe and explain the trend in atomic radius for the elements sodium to chlorine.

trend ....

....

explanation ....

.... [2]

(b) State the structure and bonding present in the elements sodium, silicon and chlorine.
How does the bonding present help to explain the variation in electrical conductivity of these elements?

sodium ....

....

....

silicon ....

....

....

chlorine ....

....

[6]

(c) **(i)** Describe the structure of a ^{35}Cl atom, in terms of number and type of sub-atomic particles.

....

.... [2]

(ii) State the electronic configuration of a chloride ion, Cl^-.

.... [1]

(d) Chlorine forms a compound, ClO_2, with oxygen, which exist as covalent molecules.

(i) Draw a dot-and-cross diagram to illustrate the bonding in a ClO_2 molecule, showing the outermost shell electrons only.

[1]

(ii) Explain why ClO_2 is a non-linear molecule.

....

....

.... [2]

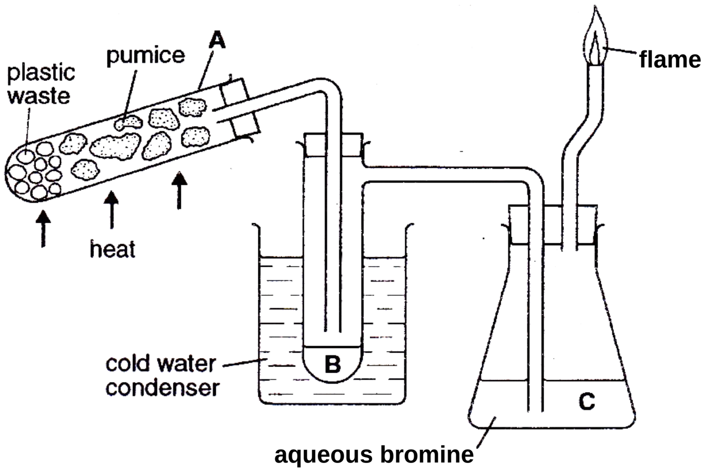
[Total: 16]

3 **(a)** In some countries, combustion is used in the disposal of plastic waste containing poly(ethene) and poly(propene).

(i) Construct an equation for the complete combustion of poly(propene), taking its formula to be $C_{3n}H_{6n}$, where n is the number of repeat units in a polymer molecule.

.... [1]

One method of recycling plastic waste to produce useful organic products involves heating the plastic waste strongly and passing the vapours over a hot inert surface such as pumice. This process can be demonstrated in the laboratory as shown in the diagram below.



The products of heating poly(propene) are given in the table.

product	percentage
hydrogen	12
methane	24
ethene	12
propene	16
benzene	20
methylbenzene	10
carbon	6

(ii) What will be the main constituent of the residue left in tube **A**, after it has been heated for an extended period of time?

.... [1]

(iii) What are the products that will be collected in tube **B** with the side-arm?

.... [1]

(iv) What will you observe in flask **C** after tube **A** has been heated for some time?

....

Write a balanced equation for the reaction that may have occurred in flask **C**.

.... [2]

(v) Suggest an advantage (economical or environmental) of this method of plastic waste disposal over the combustion method.

....

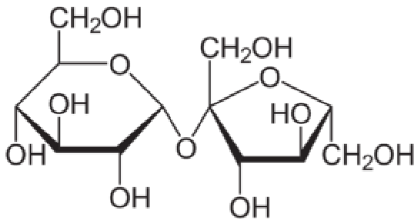
.... [1]

(b) Using an alkene with six carbon atoms, draw labelled structures to illustrate *cis-trans* isomerism.

[2]

[Total: 8]

4 Sugar is composed of sucrose, $C_{12}H_{22}O_{11}$. It is used as a sweetener in many foods and drinks. Carbonated soft drinks typically contain about 110 g of sucrose per dm^3.



sucrose

Carbonated drinks are often sold in 330 cm^3 cans.

(a) **(i)** Calculate the mass of sucrose, in grams, that is present in a can of carbonated soft drink.

mass of sucrose = ... [1]

(ii) Calculate the number of moles of sucrose in your answer to **(a)(i)**.

number of moles of sucrose = ... [2]

When the body uses sucrose in respiration, it does so by first breaking down the sucrose into glucose, $C_6H_{12}O_6$, and then releasing energy according to the following equation.

$$C_6H_{12}O_6(s) + 6O_2(g) \rightarrow 6CO_2(g) + 6H_2O(l)$$

However, the respiration of sucrose can be represented as follows.

$$C_{12}H_{22}O_{11}(s) + 12O_2(g) \rightarrow 12CO_2(g) + 11H_2O(l)$$

The data for some enthalpy changes of formation are in the table below.

compound	$\Delta H^{\ominus}_f$ / kJ mol^{-1}
$C_6H_{12}O_6(s)$	−1271
$CO_2(g)$	−394
$H_2O(l)$	−286
$C_{12}H_{22}O_{11}(s)$	−2226

The energy content of most carbonated soft drinks is usually stated with units of ‘calories’ on the nutrition information label. One calorie has the value of 4.2 kJ. On average, the daily calorie intake for men should be 2500 and for woman 2000.

(b) **(i)** Calculate the standard enthalpy change, in kJ mol^{-1}, for the respiration of sucrose.

$\Delta H^{\ominus}$ = ... [3]

(ii) Use your results from **(a)(ii)** and **(b)(i)** to calculate the quantity of energy that is available from the sucrose contained in a can of carbonated soft drink.

energy = [1]

(iii) Calculate the percentage of a man's recommended daily calorie intake he will consume by drinking a can of carbonated soft drink.

percentage = ... [2]

[Total: 9]

Section B

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

5 The reaction between propanoic acid and ethanol in the presence of concentrated sulfuric acid to form ethyl propanoate is a *reversible reaction*.

$$CH_3CH_2COOH(l) + CH_3CH_2OH(l) \rightleftharpoons CH_3CH_2COOCH_2CH_3(l) + H_2O(l)$$

propanoic acid   ethanol   ethyl propanoate

(a) **(i)** What is meant by the term *reversible reaction*? [1]

(ii) Write an expression for the equilibrium constant, K_c, for the reaction between propanoic acid and ethanol shown above. [1]

(iii) Calculate the concentration of ethanol at equilibrium when the concentrations of $CH_3CH_2COOH(l)$, $CH_3CH_2COOCH_2CH_3(l)$ and $H_2O(l)$ are 0.18 mol dm^{-3}, 1.15 mol dm^{-3} and 1.15 mol dm^{-3} respectively.

The numerical value of K_c for this reaction is 3.94. [2]

(b) Propanoic acid can be made from different classes of compounds. Apart from an ester, choose **two** starting organic compounds that have **different** functional groups that can be converted to propanoic acid. Describe the reactions to form propanoic acid including reagents, equations and any observations in your answer. [8]

(c) When a small piece of sodium is added to propanoic acid, a steady flow of bubbles is produced and a sodium salt is formed. Potassium will react with propanoic acid in a similar way.

(i) Write an equation for the reaction of potassium with propanoic acid. [1]

(ii) State what type of reaction this is. [1]

(iii) State how you would identify the gas evolved. [1]

(iv) Predict how the observations for this reaction compare with that of sodium.
Suggest an explanation in terms of atomic structure. [2]

(d) Methyl butanoate is isomeric with ethyl propanoate. Write equations to show how methyl butanoate undergoes hydrolysis using HCl(aq) and NaOH(aq). [3]

[Total: 20]

6 **(a)** Explain the terms *order of reaction* and *half-life*. [2]

(b) A chemist investigated the reaction between $H_2(g)$ and NO(g) at 300 °C.

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

The following data were obtained.

experiment	initial concentration of $H_2(g)$ / mol dm^{-3}	initial concentration of NO(g) / mol dm^{-3}	initial rate / mol dm^{-3} h^{-1}
1	2.0×10^{-3}	3.0×10^{-3}	3.0×10^{-3}
2	2.0×10^{-3}	6.0×10^{-3}	1.2×10^{-2}
3	4.0×10^{-3}	6.0×10^{-3}	2.4×10^{-2}

(i) Use the data above to deduce the order of reaction with respect to each of the two reagents, showing how you arrive at your answers.

Hence, write a rate equation for the reaction. [3]

(ii) Calculate a value for the rate constant and state its units. [2]

(c) The chemist repeated experiment 1 at 310 °C and found that the initial rate of reaction was approximately double of that at 300 °C.

(i) Draw a graph to show the **energy distribution** of gas molecules at 300 °C.
Label this curve 300 °C. [1]

(ii) On the same axes, sketch the energy distribution of the same gas molecules at a temperature of 310 °C.
Clearly label this curve 310 °C. [1]

(iii) Indicate an activation energy on your graph. [1]

(iv) Use the sketches that you have drawn **and** the collision theory to explain why an increase in temperature causes an increase in the rate of the reaction. [3]

(d) In water, NO(g) reacts with oxygen and water to form nitrous acid, HNO_2, which is a *weak* acid.

(i) What is meant by the term *weak* acid?
Illustrate your answer with an equation. [2]

(ii) Write an expression for the acid dissociation constant. K_a, of nitrous acid, and state its units. [2]

(ii) Calculate the hydrogen ion concentration, [H^+], of a solution of nitrous acid of pH 3.72. [1]

(e) A solution containing nitrous acid, HNO_2, and sodium nitrite, $NaNO_2$, can act as a buffer solution.

Write two equations to show how such a solution behaves as a buffer when a small amount of acid or alkali is added. [2]

[Total: 20]

7 **(a)** Carbon is a major constituent of organic compounds, often combined with the elements, hydrogen and oxygen. One such compound is **D**, which contains C, 66.7%; H, 11.1%; O, 22.2% by mass. The relative molecular mass of **D** is 72.0.

(i) Determine the empirical formula and the molecular formula of **D**. [3]

(ii) **D** is a ketone. Draw its displayed formula. [1]

(b) Compound **E** has the molecular formula C_3H_8O. When **E** is heated with acidified potassium dichromate(VI), $K_2Cr_2O_7$, it forms compound **F**.

F gives a yellow precipitate in the presence of alkaline aqueous iodine, and an orange precipitate in the presence of 2,4-dinitrophenylhydrazine.

When **E** is heated with aqueous sodium bromide and concentrated sulfuric acid, it forms compound **G**. When a solution of silver nitrate in ethanol is added to **G**, a pale cream precipitate appears after a few minutes. When **G** is heated under reflux with concentrated sodium hydroxide in ethanol, compound **H** is formed.

H decolourises aqueous bromine.

Identify and suggest structures for **E**, **F**, **G** and **H**. Show how you deduced these structures, write equations for all of the reactions described above and suggest the types of reactions that are occurring. [10]

(c) Methylbenzene is an important intermediate in organic synthesis. It can undergo two different types of reactions with chlorine, depending on the conditions of the reaction.

For each type of reaction, give the conditions used and draw the structural formulae of the organic product formed. [4]

(d) Chlorofluoroalkanes, CFCs, have been banned as refrigerants and aerosol propellants in many countries since the mid-1990s. Suggest why CFCs have been banned and why fluoroalkanes such as CH_2FCF_3 are used as their replacements. [2]

[Total: 20]

~ END OF PAPER ~

2017 H1 Chemistry 8872 Preliminary Examinations Suggested Answers

Paper 2 Section A: Structured Questions

1 (a) (i) $Al(OH)_3 + 3H^+ \rightarrow Al^{3+} + 3H_2O$
(or $Al(OH)_3$ reacting with HCl)

(ii) Aluminium hydroxide or calcium carbonate is **insoluble in water** and therefore **will not increase the pH** of blood.

(b) (i)
$$n_{CO_2} = \frac{550}{22400} = 0.024554 = 0.0246 \text{ mol}$$

(ii)
$$n_{CaCO_3} = n_{CO_2} = 0.0246 \text{ mol}$$
$$m_{CaCO_3} = 0.024554 \times \{40.1 + 12.0 + 3(16.0)\} = 0.024554 \times 100.1 = 2.4565 = 2.46 \text{ g}$$

(iii) mass of $CaCO_3$ in one tablet = $\frac{2.4565}{5} = 0.491$ g
The claim is valid, as the mass if $CaCO_3$ is approximately the same as what was claimed by the manufacturer

[Total: 7 marks]

2 (a) (i) The melting point of the elements **increases from Na to Si** (with Si significantly higher than that for A*l*),
The melting point **decreases drastically from Si to P** and is relatively low from P to C*l* (or the melting point of P to C*l* is much lower than that for the Na to Si).

(ii) trend: atomic radius **decreases** from Na to C*l*
explanation: **nuclear charge increases** and **shielding effect remains constant**

(b) sodium:
metallic bonding and **giant metallic structure**
'sea' of delocalised electrons are available to conduct electricity and so it has **high electrical conductivity**

silicon:
covalent bonding and **giant molecular structure or giant covalent structure**
In the giant molecular structure, there are some free electrons and 'holes' which can be used to conduct electricity, and so **silicon is a semi-conductor**

chlorine:
covalent bonding and **simple molecular structure**
There are **no mobile electrons** to conduct electricity, and so chlorine is a **non-conductor**

(c) (i) There are **17 protons and 18 neutrons** concentrated (within a very small volume) **at the nucleus / centre of the atom**
There are **17 electrons surrounding the nucleus** and moving randomly

(ii) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5$

(d) **(i)**

(ii) There are **<u>two bond pairs and two lone pairs</u>** of electrons (allow e.c.f.)
Hence the **<u>electron pairs spread themselves out as far apart as possible to minimise repulsion</u>** giving rise to the **<u>bent</u>** shape.

[Total: 16 marks]

3 **(a)** **(i)** $\mathbf{C_{3n}H_{6n}} + \frac{9n}{2}\mathbf{O_2} \rightarrow (3n)\mathbf{CO_2} + (3n)\mathbf{H_2O}$

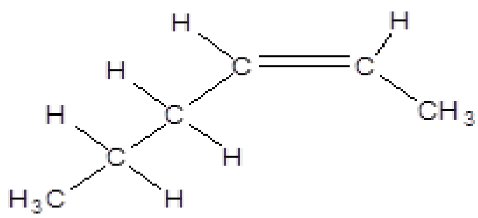
(ii) carbon (soot)

(iii) benzene and methyl benzene

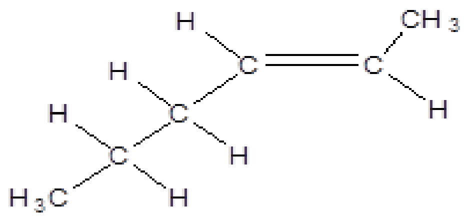
(iv) brown Br_2(aq) is decolourised
$CH_2CH_2 + Br_2 + H_2O \rightarrow BrCH_2CH_2OH + HBr$
or
$CH_2CH_2 + Br_2 \rightarrow BrCH_2CH_2Br$
(accept equations involving propene as well)

(v) hydrogen and methane collected can be used as fuels.
or
benzene collected (in tube B) can be used to manufacture styrene and phenol
or
reduce the emission of CO_2(g) to the atmosphere
(accept any other reasonable answer)

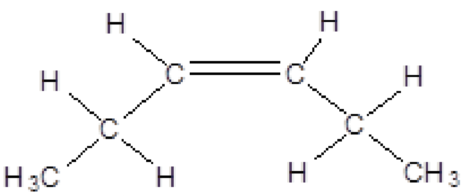
(b)



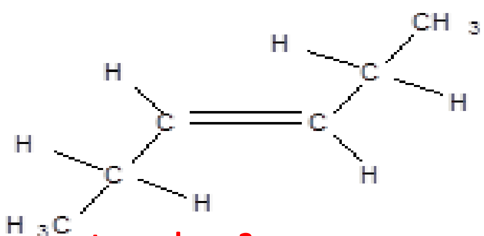
cis–hex–2–ene



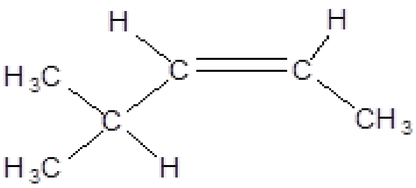
trans–hex–2–ene



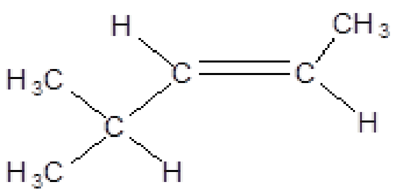
cis–hex–3–ene



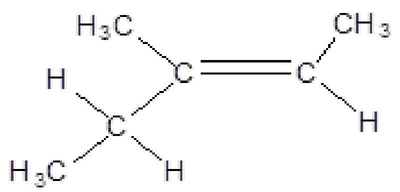
trans–hex–3–ene



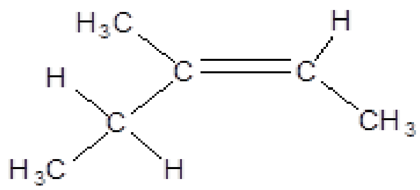
cis–4–methylpent–2–ene



trans–4–methylpent–2–ene



cis–3 – methylpent – 2 – ene



trans–3 – methylpent – 2 – ene

[Total: 8 marks]

4 (a) (i) mass of sucrose = $110 \times 330 \times 10^{-3} = 36.3 \text{ g}$

(ii) M_r of sucrose = $12(12.0) + 22.0 + 11(16.0) = 342.0$

number of moles of sucrose = $\dfrac{36.3}{342.0} = 0.10614 = 0.106 \text{ mol}$

(b) (i) **$\Delta H_{rxn}^{\ominus} = \Sigma\Delta H_f^{\ominus}$(products) − $\Sigma\Delta H_f^{\ominus}$(reactants)**

= $12\Delta H_f^{\ominus}(CO_2) + 11\Delta H_f^{\ominus}(H_2O) - \Delta H_f^{\ominus}(C_{12}H_{22}O_{11})$

= 12(−394) + 11(−286) − (−2226)

= −7874 + 2226

= −5648 kJ mol^{-1} (or −5650 kJ mol^{-1} to 3 s.f.)

[1] for correct equation, i.e. coefficient of the terms (for sucrose, not glucose)
[1] for correct substitution of the values (regardless of correct equation or not)
[1] for correct final answer with units

(ii) quantity of energy = $5648 \times 0.10614 = 599.48 = 599 \text{ kJ}$ (allow e.c.f.)

(iii) number of 'calories' = $\dfrac{599.48}{4.2} = 142.73$

percentage = $\dfrac{142.73}{2500} \times 100\% = 5.71\%$

[Total: 9 marks]

Paper 2 Section B: Free Response Questions

5 (a) (i) A reversible reaction is one that can proceed in both the forward and the backward direction.

(ii)

$$K_c = \frac{[CH_3CH_2COOCH_2CH_3][H_2O]}{[CH_3CH_2COOH][CH_3CH_2OH]}$$

(iii)

$$K_c = \frac{[CH_3CH_2COOCH_2CH_3][H_2O]}{[CH_3CH_2COOH][CH_3CH_2OH]}$$

$$3.94 = \frac{(1.15)(1.15)}{(0.18)[CH_3CH_2OH]}$$

$$\Rightarrow [CH_3CH_2OH] = \frac{(1.15)(1.15)}{(0.18)(3.94)} = 1.86 \text{ mol dm}^{-3}$$

(b) $$CH_3CH_2CH_2OH + 2[O] \xrightarrow[H_2SO_4(aq),\ \text{heat under reflux}]{KMnO_4 \text{ or } K_2Cr_2O_7} CH_3CH_2CO_2H + H_2O$$

Observation:
Purple $KMnO_4$ is decolourised.
Or Orange $K_2Cr_2O_7$ turns green.

$$CH_3CH_2CHO + [O] \xrightarrow[H_2SO_4(aq),\ \text{heat under reflux}]{KMnO_4 \text{ or } K_2Cr_2O_7} CH_3CH_2CO_2H$$

Observation:
Purple $KMnO_4$ is decolourised.
Or Orange $K_2Cr_2O_7$ turns green.

$$CH_3CH_2CN + 2H_2O + H^+ \xrightarrow{H_2SO_4(aq),\ \text{heat under reflux}} CH_3CH_2CO_2H + NH_4^+$$

Observation:
No visible observation.

$$CH_3CH_2CH{=}CH_2 + 5[O] \xrightarrow[H_2SO_4(aq),\ \text{heat under reflux}]{KMnO_4} CH_3CH_2CO_2H + H_2O + CO_2$$

Observation:
Purple $KMnO_4$ is decolourised. Effervescence is observed, and gas evolved forms white precipitate with limewater.

(c) **(i)** $2K + CH_3CH_2COOH \rightarrow 2CH_3CH_2COO^-K^+ + H_2$

(ii) Redox reaction (accept acid-metal / base reaction)

(iii) The gas will **<u>'pop' with a lighted splint</u>**

(iv) The effervescence / bubbling will be more vigourous
As K is a bigger atom than Na (or K has a larger atomic radius than Na, or the outermost electron of K is further away from the nucleus than Na), **<u>the outermost electron of K is more loosely held by the nucleus</u>** (or the attractive force between the outermost electron and the nucleus of K is weaker) than Na,
$\Rightarrow$ K **<u>undergoes oxidation</u>** to form K^+ **<u>more easily</u>**

(d) Using HC*l*(aq):

$$CH_3CH_2CH_2-\overset{\overset{\displaystyle O}{||}}{C}-O-CH_3 + H_2O \rightleftharpoons CH_3CH_2CH_2-\overset{\overset{\displaystyle O}{||}}{C}-OH + CH_3-OH$$

Using NaOH(aq):

$$CH_3CH_2CH_2-\overset{\overset{\displaystyle O}{||}}{C}-O-CH_3 + NaOH \longrightarrow CH_3CH_2CH_2-\overset{\overset{\displaystyle O}{||}}{C}-O^-Na^+ + CH_3-OH$$

correct structure of methylbutanoate

[Total: 20 marks]

6 (a) **order of reaction** with respect to a given reactant is the **power** to which the **concentration of that reactant is raised** in **an experimentally determined rate equation**
or
In an experimentally determined rate equation : Rate = k [A] ^{m}
m = order of reaction with respect to reactant A
The **half-life** of a reaction, $t_{1/2}$, is the time taken for the concentration of a reactant to fall to **exactly half** its value

(b) (i) Comparing experiment 1 and 2,
When [NO] is doubled, the initial rate is quadrupled
⇒ order of reaction with respect to NO is 2
Comparing experiment 2 and 3,
When [H_2] is doubled, the initial rate is doubled
⇒ order of reaction with respect to H_2 is 1
rate = k [H_2] [NO]^2

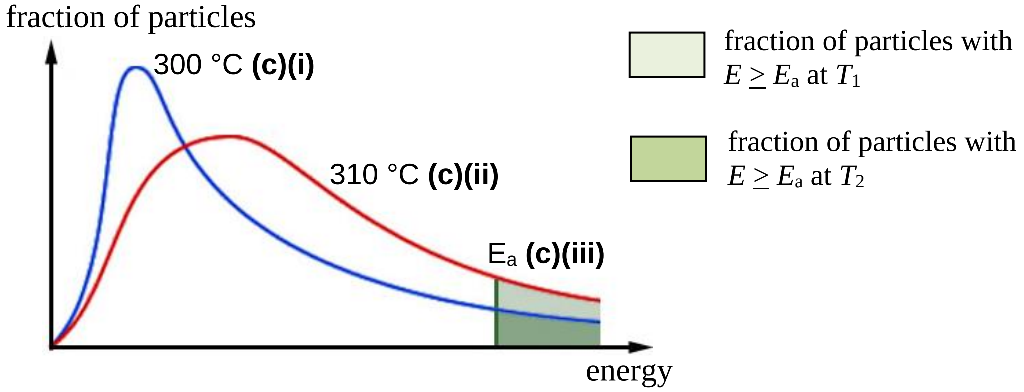
(ii) Using the values from experiment 1:

$$3.0\times10^{-3} = k(2.0\times10^{-3})(3.0\times10^{-3})^2$$

$$\Rightarrow k = \frac{3.0\times10^{-3}}{(2.0\times10^{-3})(3.0\times10^{-3})^2} = 1.67\times10^{5}\ \text{mol}^{-2}\ \text{dm}^{6}\ \text{h}^{-1}$$

[1] for correct value, [1] for units (allow e.c.f. for both)

(c) (i)-(iii)



(iv) When temperature increases, the reactant particles have **greater average kinetic energies**, and the frequency of collisions increase

As seen from the diagram, **a larger fraction of the reactant particles** will have kinetic **energies greater than or equal to the activation energy**, and so the **frequency of effective collisions increases**

Hence, the **rate constant, *k*, increases** leading to the increase in the rate of the reaction.

(d) (i) A *weak* acid is one that dissociates partially in water
$HNO_2 \rightleftharpoons H^+ + NO_2^-$

(ii)

$$K_a = \frac{[H^+][NO_2^-]}{[HNO_2]}$$

units = mol dm^{-3}

(iii) $[H^+] = 10^{-3.72} = 1.91\times10^{-4}\ \text{mol dm}^{-3}$

(e) $HNO_2 + OH^- \rightarrow NO_2^- + H_2O$
$NO_2^- + H^+ \rightarrow HNO_3$ (accept if students use H_3O^+)

[Total: 20 marks]

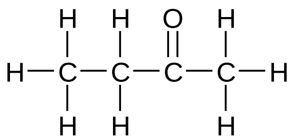
7 (a) (i)

	C	H	O
mass ratio	66.7	11.1	22.2
mole ratio	$\frac{66.7}{12.0}=5.5583$	$\frac{11.1}{1.0}=11.1$	$\frac{22.2}{16.0}=1.3875$
	$\frac{5.5583}{1.3875}=4.00$	$\frac{11.1}{1.3875}=8.00$	$\frac{1.3875}{1.3875}=1.00$

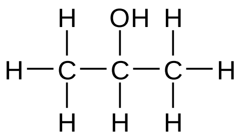
$\Rightarrow$ empirical formula of **D** is C_4H_8O

molecular formula = $(C_4H_8O)_n$
$\Rightarrow M(C_4H_8O)_n = n \times \{4(12.0)+8.0+16.0\} = 72.0$
$\Rightarrow n \times (72.0) = 72.0$
$\Rightarrow n = 1$

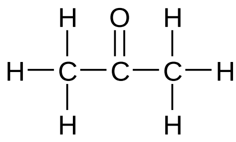
(ii)



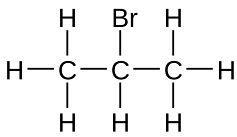
(b)



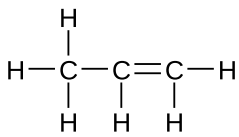
E



F



G



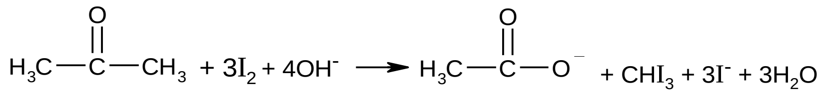
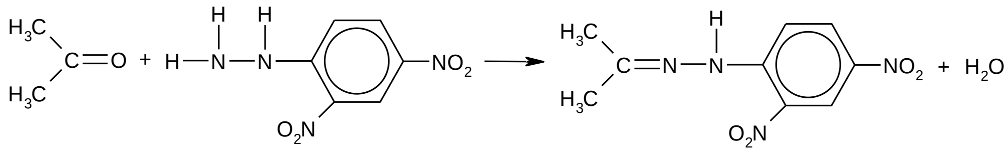
H

[1] each

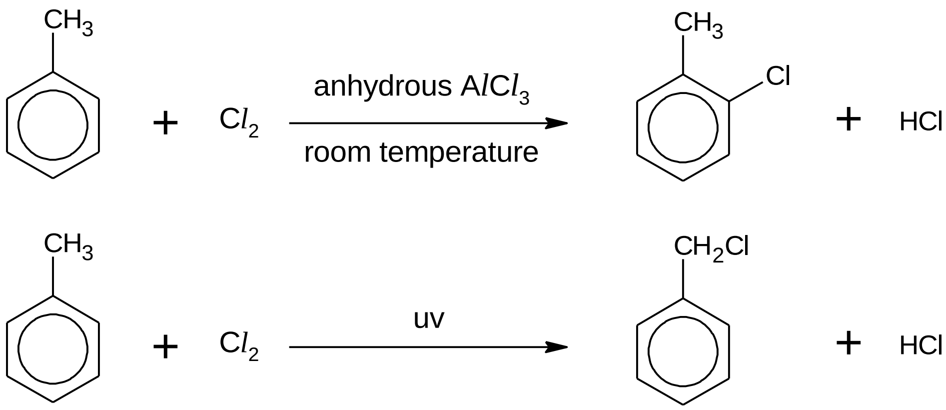
	information	type of reaction	deductions
1	When **E** is heated with acidified potassium dichromate(VI), $K_2Cr_2O_7$, it forms compound **F**	oxidation	**E** must be an alcohol (its formula is C_3H_8O), and **F** must be either a ketone or carboxylic acid (as no mention of immediate distillation)
2	**F** gives a yellow precipitate in the presence of alkaline aqueous iodine	oxidation	**F** must be a ketone that has the structure $-COCH_3$ (not an alcohol due to pt 1)
3	**F** gives an orange precipitate in the presence of 2,4-dinitrophenylhydrazine.	condensation	**F** must be a ketone (not an aldehyde due to pt 1&2)
4	When **E** is heated with aqueous sodium bromide and concentrated sulfuric acid, it forms compound **G**	(nucleophilic) substitution	**E** must be an alcohol and **G** must be a bromoalkane

5	When a solution of silver nitrate in ethanol is added to **G**, a pale cream precipitate appears after a few minutes	(nucleophilic) substitution + precipitation	**G** must be a bromoalkane, (as it undergo hydrolysis (there is usually water present) to produce Br^- ion, which forms a cream ppt with $AgNO_3$)
6	When **G** is heated under reflux with concentrated sodium hydroxide in ethanol, compound **H** is formed	elimination (of HBr)	**G** must be a bromoalkane and **H** must be an alkene
7	**H** decolourises aqueous bromine.	(electrophilic) addition	**H** must be an alkene

Equations:

1. $CH_3CH(OH)CH_3 + [O] \rightarrow CH_3COCH_3 + H_2O$
2. 
3. 
4. $CH_3CHOHCH_3 + HBr \rightarrow CH_3CHBrCH_3 + H_2O$
5. $CH_3CH_2Br + H_2O \rightarrow CH_3CH_2OH + HBr$
   and $Ag^+ + Br^- \rightarrow AgBr$
6. $CH_3CH(OH)CH_3 \rightarrow CH_3CH{=}CH_2 + H_2O$
   $CH_3CH{=}CH_2 + Br_2 + H_2O \rightarrow CH_3CH(OH)CH_2Br + HBr$
7. or
   $CH_3CH{=}CH_2 + Br_2 \rightarrow CH_3CH(Br)CH_2Br$

(c)



(d) CFCs cause the depletion of the ozone layer (or caused the hole in the ozone layer) Fluoroalkanes such as CH_2FCF_3 does not have C−C*l* bonds, which will break easily under uv light to produce C*l*· radicals (or does not have C*l*-atoms, and so will not produce C*l*· radicals)

[Total: 20 marks]

~ END OF SUGGESTED ANSWERS ~