2017 H1 Chemistry 8872 Preliminary Examinations
Suggested Answers

Paper 2 Section A: Structured Questions

1 **(a)** **(i)** A*l*(OH)$_3$ + 3H$^+$ $\rightarrow$ A*l*$^{3+}$ + 3H$_2$O
(or A*l*(OH)$_3$ reacting with HC*l*)

(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 = $\frac{2.4565}{5} = 0.491 \text{ g}$
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 **two bond pairs and two lone pairs** of electrons (allow e.c.f.)
Hence the **electron pairs spread themselves out as far apart as possible to minimise repulsion** giving rise to the **bent** shape.

[Total: 16 marks]

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

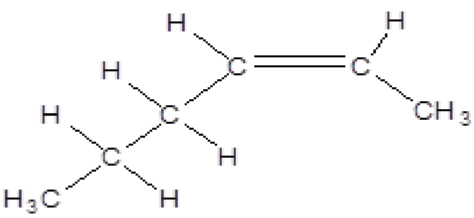
(ii) carbon (soot)

(iii) benzene and methyl benzene

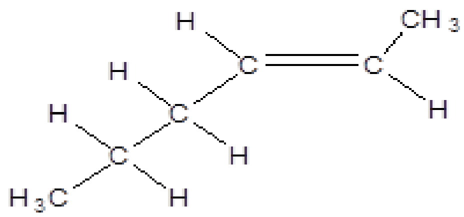
(iv) brown $Br_2(aq)$ is decolourised
$CH_2CH_2 + Br_2 + H_2O \rightarrow BrCH_2CH_2OH + HBr$
or
$CH_2CH_2 + Br_2 \rightarrow BrCH_2CH_2Br$
(accept equations involving propene as well)

(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)

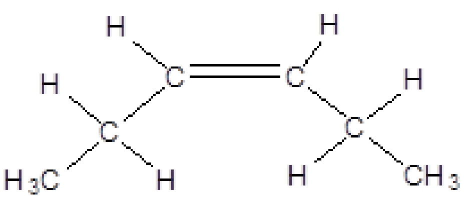
(b)



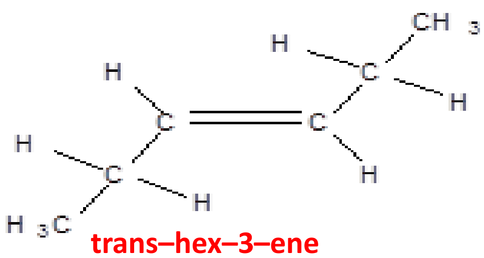
cis–hex–2–ene



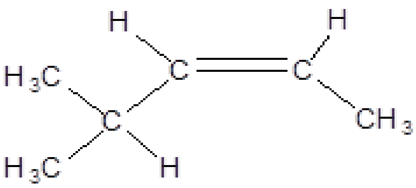
trans–hex–2–ene



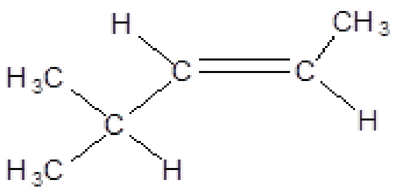
cis–hex–3–ene



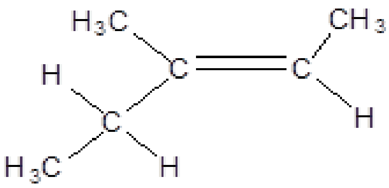
trans–hex–3–ene



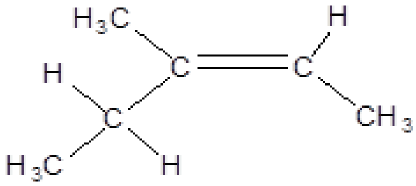
cis–4–methylpent–2–ene



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 = $\frac{36.3}{342.0} = 0.10614 = 0.106 \text{ mol}$

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

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

$= 12(-394) + 11(-286) - (-2226)$

$= -7874 + 2226$

$= -5648 \text{ kJ mol}^{-1}$ (or $-5650 \text{ kJ mol}^{-1}$ 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' = $\frac{599.48}{4.2} = 142.73$

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

[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):

$$CH_3CH_2CH_2-C(=O)-O-CH_3 + H_2O \rightleftharpoons CH_3CH_2CH_2-C(=O)-OH + CH_3-OH$$

Using NaOH(aq):

$$CH_3CH_2CH_2-C(=O)-O-CH_3 + NaOH \longrightarrow CH_3CH_2CH_2-C(=O)-O^-Na^+ + CH_3-OH$$

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

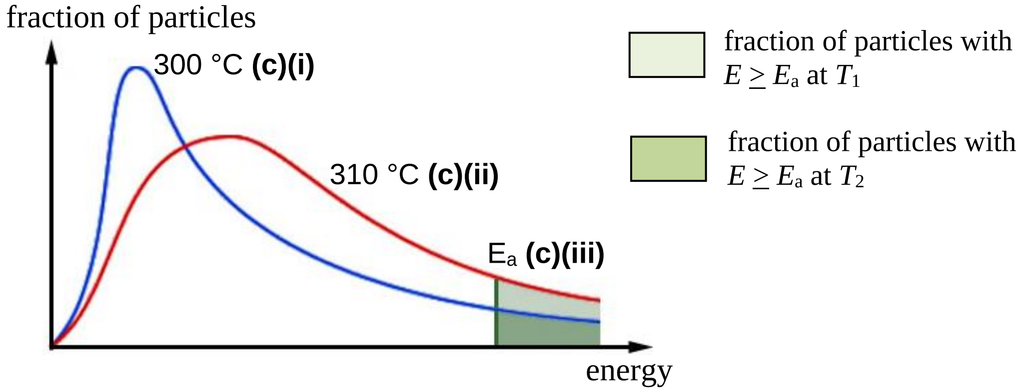
(ii) Using the values from experiment 1:

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

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

[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]

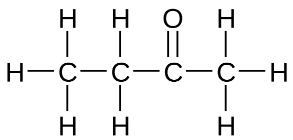
7 **(a)** **(i)**

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

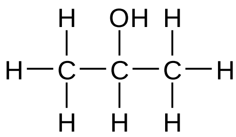
$\Rightarrow$ empirical formula of **D** is C_4H_8O

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

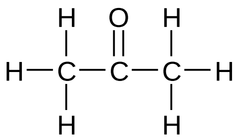
(ii)



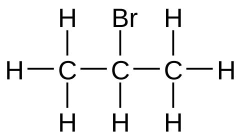
(b)



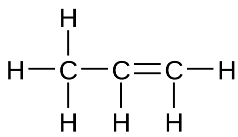
E



F



G



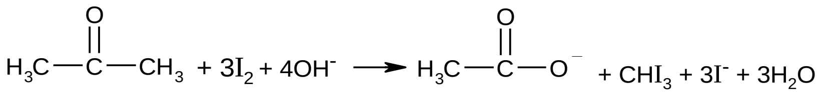
H

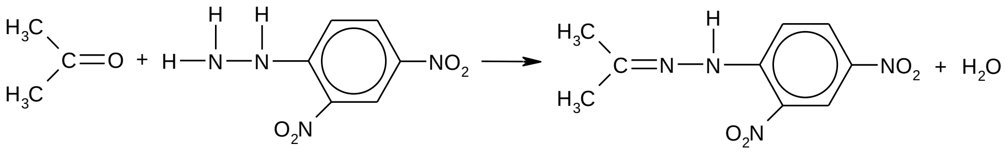
[1] each

	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

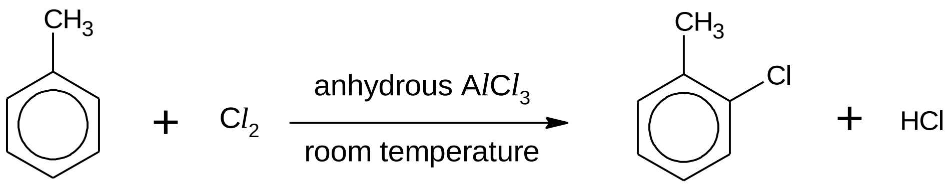
Equations:

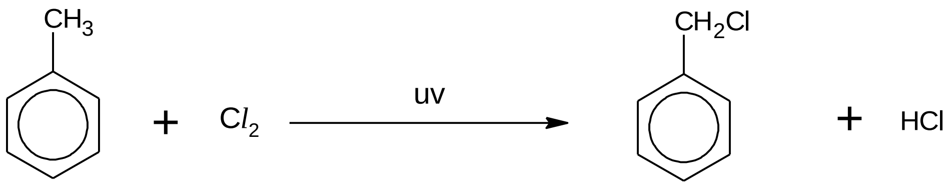
1. $CH_3CH(OH)CH_3 + [O] \rightarrow CH_3COCH_3 + H_2O$
2. 

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. $CH_3CH(OH)CH_3 \rightarrow CH_3CH{=}CH_2 + H_2O$
7. $CH_3CH{=}CH_2 + Br_2 + H_2O \rightarrow CH_3CH(OH)CH_2Br + HBr$
   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 ~