Mark Scheme

Paper 2 Theory
Section A

1

salt	barium sulfate	copper(II) nitrate
reagent 1	aqueous barium nitrate	dilute nitric acid
reagent 2	***aqueous sodium sulfate*** – 1m *or any solution containing SO_4^{2-}*	***copper(II) oxide/hydroxide/carbonate*** – 1m
description on how to obtain solid product from reaction mixture	**Filter** the mixture to collect barium sulfate as **residue**. – 1m	**Filter** to collect copper(II) nitrate as **filtrate**. – 1m **Heat to evaporate** the mixture until **saturated**. – 1m **Cool** for crystals to **form**. **Filter** the mixture to **collect** copper(II) nitrate crystals as **residue**. –1m

accept any other suitable reagents [6]

2 **(a)** **(i)** Cotton wool changes colour from **colourless to red-brown/brown**. [1]

(ii) **Chlorine, being more reactive than bromine**, can displace **bromine from sodium bromide to form red-brown bromine** and sodium chloride. [1]

$Cl_2 + 2Br^- \rightarrow Br_2 + 2Cl^-$ [1]

(b) **sodium iodide** [1]

3 **(a)** **BO_3^{3-}** [1]

(b) For the **same concentration of acids** used, the **pH of hydrochloric acid is 1.30, which is lower than that of boric acid at 5.25.** [1]
As a weak acid, boric acid only **ionises partially in water** to form H^+, producing a **lower concentration of H^+,** hence resulting in higher pH. [1]

(c) **(i)** **Insert lighted splint to the gas.** [1]
Lighted splint extinguishes with a '**pop**' sound if gas is **hydrogen**. [1]

(ii) The final volume of gas produced will be the **same**. [1]
For both reactions, the zinc to gas mole ratio is the same. Since the **zinc is the limiting reagent/same number of moles of zinc**, the final volume of gas produced will be the same. [1]

4 **(a)** **locating agent** is added to react with the amino acids to **form coloured spots**. [1]

(b) **S** is the most soluble as its ***R*$_f$ value is the highest** with both solvents. [1]
Since ***R*$_f$ is the ratio between distance travelled by spot to distance travelled by solvent,** highest *R*$_f$ means **it travelled the furthest** from the start line. [1]

(c) **Solvent 2** as **all the amino acids are soluble in solvent 2.** [1]
***R*$_f$ value for Q in solvent 1 is 0.00,** which means it is **insoluble in the solvent**. [1]

5 **(a)** Mass of 1 mol of octane = 12 x 8 + 18 x 1 = 114 g
Vol of 1 mol of octane = mass/density = 114 / 703 = **0.162 dm^3** [1]

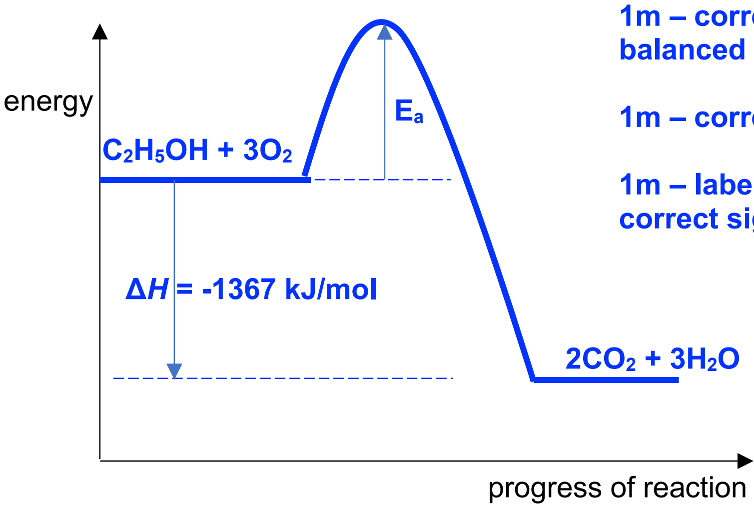
No. of mol of 1 kg of ethanol = 1000/(12 x 2 + 6 x 1 + 16) = 21.739 mol [1]
ΔH when 1 kg of ethanol is completely burnt = –1367 x 21.739 = **–29717 kJ** [1]

(b) Propane exists as a **gas** at room temperature and pressure, **takes up more volume per mole**/**a lot of it is required to be stored** to be effectively used **as a fuel**. Ethanol exists as a **liquid** at room temperature and can be **stored more easily**/**more closely packed** (**24.3dm^3 compared to 0.0583dm^3**) [1]

Propane **produces more energy per kilogram** compared to ethanol when completely burnt **(–50 455 kJ/kg compared to –29 717 kJ/kg).** [1]

Propane is produced from **non-renewable crude oil** while ethanol can be produced from **renewable sugarcane/corn**. [1]

(c)



1m – correct formulae and balanced eqn

1m – correct shape of graph

1m – label E_a and Δ*H* with correct sign and value with units

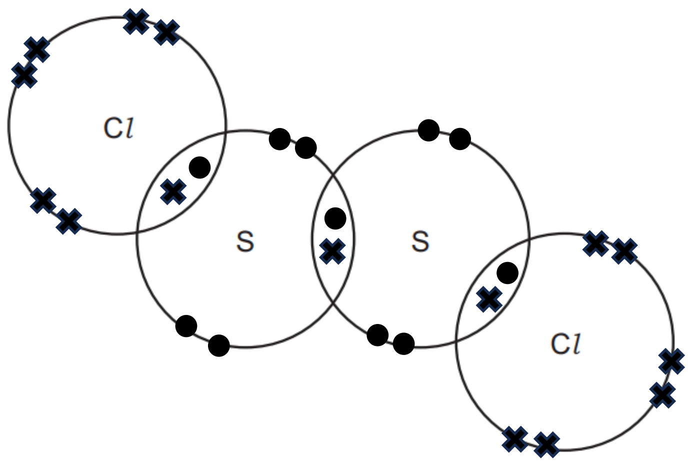
[3]

(d) During **photosynthesis, plants take in carbon dioxide** and water to make glucose and oxygen in the presence of sunlight. [1]

6 **(a)** Zinc sulfide has a **giant molecular structure** while disulfur dichloride has a **simple molecular structure**. [1]
Large amount of energy is needed to break the **strong covalent bonds** between the zinc and sulfur atoms. [1]
Little energy is required to overcome **weak intermolecular forces of attraction between disulfur dichloride molecules**. [1]
Hence zinc sulfide it has a **high melting point** while disulfur dichloride has a **low boiling point**. [1]

(b) **poor electrical conductivity/insoluble in water** [1]

(c)



[2]

bonding electrons – 1m
valence electrons – 1m

7 **(a)** experiment 1: **copper** [1]
experiment 2: **platinum/graphite** [1]

(b) Mass of both A_1 and B_1 increases:
Cu is less reactive than H hence Cu^{2+} is preferentially discharged over H^+, gaining electrons and is **reduced** to form copper solid. [1]
Cu^{2+} (aq) + 2e → Cu (s) [1]

Mass of A_2 has decreased:
Since **electrode is reactive**, copper electrode loses electrons and gets **oxidised** at the anode to form copper ions. [1]
Cu (s) → Cu^{2+} (aq) + 2e [1]

Effervescence observed at B_2:
Since electrode at B is inert, mass of B_2 remained unchanged. **OH^- is preferentially discharged over SO_4^{2-},** loses electrons and gets **oxidised** to form oxygen gas, hence effervescence observed. [1]
$4OH^-$ (aq) → $2H_2O$ (*l*) + O_2 (g) + 4e [1]

(c) Copper(II) sulfate **remains blue in experiment 1** because **copper electrode/anode** is oxidised to **form Cu^{2+}** which **replenishes** the Cu^{2+} ions from the electrolyte is used for reduction at A_1. **Overall concentration of Cu^{2+} ions remains unchanged**. [1] [1]
Copper(II) sulfate **turns pale blue/colourless in experiment 2** because **Cu^{2+} ions from the electrolyte is reduced to form Cu** at B_1, **decreasing overall concentration of Cu^{2+} ions in the electrolyte.** [1]

both ob – 1m; both reasoning – 1m; concentration – 1m
or both ob – 1m, reasoning + conc for each – 1m each

8 **(a)** **(i)** high carbon steel [1]

(ii) Presence of **different sized carbon atoms** **disrupt the orderly arrangement of iron atoms,** making it **difficult for the layers of atoms to slide over each other** when a **force is applied**. [2]

1m for any 2 points

With **more carbon atoms**, there is **greater disruption** of the orderly arrangement of iron atoms in high carbon steel compared to low carbon steel and medium carbon steel hence making it harder than the other carbon steels. [1]

(b) Low carbon steel is used to make car bodies as it has the **highest ductility** hence it can be **easily moulded into shapes** without facturing. [1]
High carbon steel is used to make wire ropes for suspension bridges as it has the **highest tensile strength** hence it can **support the weight of the suspension bridge** without breaking. [1]

(c) **(i)** **Fe_2O_3 loses oxygen to form Fe** hence it is **reduced**. [1]
CO gains oxygen to form CO_2 hence it is **oxidised**. [1]
since **both oxidation and reduction occurs at the same time** in the same reaction, it is a redox reaction.

(ii) When **carbon reacts with oxygen**, reaction is **exothermic/gives out heat.** [1]

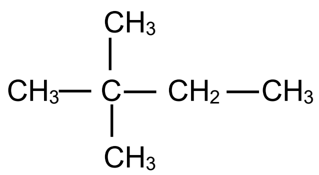
(iii) $4Fe + 3O_2 \rightarrow 2Fe_2O_3$ [1]

(d) Use of scrap steel instead of solely pure iron **reduces the need for extraction of new iron**, which **produces carbon dioxide** as by-product, which is a **greenhouse gas** that causes global warming. [1]
Addition of scrap steel absorbs excess heat and **decreases the temperature**, hence reduce possibility of **production of oxides of nitrogen,** an air pollutant that is produced due to **N_2 and O_2 reacting under high temperature**. [1]

9 **(a)** A: **neither** [1]
Pentane has the formula **C_5H_{12}** while the product has the formula **C_5H_{10}**.
B: **isomerisation** [1]
Hexane has the molecular formula of **C_6H_{14}**. The product formed also has the formula **C_6H_{14}**. Since both have the **same molecular formula but different structural formula**/arrangement of atoms in each molecule, isomerisation has occurred. [1]
C: **cracking** [1]
Heptane has the molecular formula **C_7H_{16}** while the product has the formula **C_2H_4**. Since a **long chain alkane has been broken down** to form smaller/short chain alkene as one of the products, cracking has occurred.

name of process + giving chemical formulae – 1m

(b) [1]



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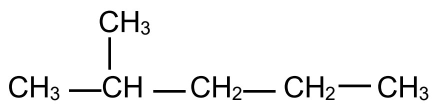
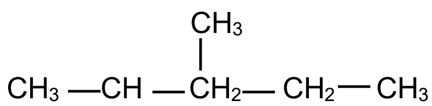




(c) When added to product in process A, **red-brown/brown aqueous bromine remains** red-brown/brown but turn **colourless/decolourise** when added to product in process B. [1]
Product in process A **do not have C=C bond** that allows for **addition of bromine** to take place while product in process B has. [1]

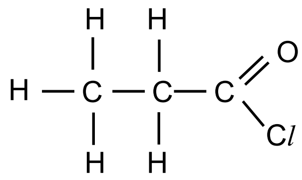
or

red-brown bromine remain unchanged for A due to **absence of C=C bond** [1]
red-brown bromine turn colourless/decolourise for B due to **presence of C=C bond** that allows for **addition of bromine.** [1]

(d) Longer chain alkanes are in lower demand and are cracked to produce short chain alkenes which are **more useful and in higher demand** in the oil industry. [1]

Section B

10 (a) [2]

<u>propanoyl chloride</u>	C_2H_5COCl	

(b) They have the same $–COCl$ functional group / [2]
successive member differ by a $-CH_2$ group /
It follows the same general formulae $C_nH_{2n+1}COCl$

any 2
reject show a gradation in physical properties

(c) (i) propyl ethanoate [1]

(ii) reaction of ethanoic acid with propanol produces **<u>water</u>** as the by-product while reaction of ethanoyl chloride with propanol produces **<u>HC*l*</u>** as the by-product. [1]

reaction of ethanoic acid with propanol requires **<u>concentrated sulfuric acid as catalyst</u>** while reaction of ethanoyl chloride with propanol takes place **<u>spontaneously</u>**. [1]

(d) (i) Assume 100g of carboxylic acid:

element	carbon	hydrogen	oxygen
mass	40.2	6.70	53.1
molar mass	12	1	16
no.of moles	40.2 / 12 = **<u>3.35</u>**	6.70 / 1 = **<u>6.70</u>**	53.1 / 16 = **<u>3.318</u>**
ratio	1	2	1

[1]

empirical formula: **<u>CH_2O</u>**

[1]

(ii) **<u>ethanoyl chloride / CH_3COCl</u>** [1]

11 (a) **<u>Experiment 2</u>** is used as a reference. To compare the effects, **<u>only one variable is changed</u>** while **<u>all the other variables are kept constant</u>**. [1]

<u>Experiments 1 & 2</u> to compare the effect of **<u>concentration of sodium carbonate</u>**, **<u>experiments 2 & 3</u>** to compare the effect of **<u>temperature,</u>** **<u>experiments 2 & 4</u>** to compare the effect of **<u>concentration of calcium chloride</u>** on the rate of reaction. [1]

(b) As the **<u>concentration</u>** of calcium chloride or sodium carbonate **<u>increases</u>**, there are **<u>more particles per unit volume</u>**. [1]
When **<u>temperature increases</u>**, **<u>particles gain energy and move faster</u>**. **<u>More particles</u>** have **<u>sufficient energy</u>** to react when collide / **<u>more particles have energy greater than or equal to activation energy</u>**. [1] [1]
This **<u>increases the frequency of effective collisions between reacting particles</u>** of $CaCl_2$ and Na_2CO_3, resulting in an **<u>increase in the rate of reaction</u>**.

(c) Using experiment 1,

Number of moles of $CaCl_2 = \frac{25}{1000} \times 0.3$

$= 0.0075$ mol

Number of moles of $Na_2CO_3 = \frac{25}{1000} \times 0.05$

$= 0.00125$ mol

By mole ratio,

$CaCl_2$	:	Na_2CO_3	
1	:	1	
0.0075	:	0.0075	(more than the 0.00125 mol present)

Hence Na_2CO_3 is the limiting reagent. [2]

both mol calculation – 1m
correct limiting reagent + reason – 1m

(d) **<u>Add aqueous sodium hydroxide</u>** to both solutions separately. [1]
<u>White precipitate</u> will be formed with calcium chloride, which is insoluble in excess, while there will be **<u>no visible change</u>** with sodium carbonate. [1]

or

<u>Add dilute nitric acid</u> to both solutions separately. [1]
<u>No visible change</u> with calcium chloride while there will be **<u>effervescence of colourless and odourless gas which forms white precipitate in limewater</u>** with sodium carbonate. [1]

or

<u>Add dilute nitric acid</u> followed by **<u>aqueous silver nitrate</u>** to both solutions separately. [1]
<u>White precipitate</u> will be formed with calcium chloride while **<u>yellow precipitate</u>** will be formed with sodium carbonate. [1]

(e) There would be **<u>no precipitate formed</u>**, hence it is **<u>not possible to record the time/time is infinite</u>** taken for light to be blocked. [1]