SPECIMEN M'SCHEME

1 (a) Solution of dichromate(VI) ions reflects orange light/ ~600 nm [1 mark]

and absorbs blue/blue-violet light /~440 nm [1 mark]

Answer must make clear that by using this wavelength the measurement is more accurate, only the light which is changing in intensity is being detected [1 mark]

[3 marks]

(b) Electrons can only occupy definite energy levels [1 mark]

Energy equal to the difference between energy levels is transferred to electrons from light [1 mark]

The energy transferred is proportional to the frequency of the light absorbed [1 mark]

[3 marks]

(c) Measure the absorbances of a number of solutions of dichromate(VI)ions [1 mark]

to which different amounts of ethanol have been added [1 mark]

[2 marks]

(d) An absorbance change of 0.45 corresponds to 103×10^{-6} mol of ethanol added [1 mark]

103×10^{-6} mol in 50×10^{-6} dm^3 is equivalent to a concentration of 2.06 mol dm^{-3} [1 mark]

2.06 mol dm^{-3} = 94.8 g dm^{-3} [1 mark]

94.8 g dm^{-3} corresponds to 120 cm^3 dm^{-3} [1 mark]

Therefore, wine is 12% ethanol **[4 marks]**

(e) Reduction of dichromate(VI) ions:

$$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$$

$2Cr^{3+} + 7H_2O$ [1 mark]

$H^+ + e^-$ on RHS equation [1 mark]

Correct balanced equation [1 mark]

Overall equation:

$$3CH_3CH_2OH + 2Cr_2O_7^{2-} + 16H^+ \rightarrow 3CH_3COOH + 4Cr^{3+} + 11H_2O$$

Attempt to combine the two half-equations and with no electrons in the overall equation [1 mark]

Correct equation [1 mark]

[5 marks]

Total 17 marks

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2 (a) (i) Answer must mention the explosive combustion of hydrogen [1 mark]
the role of the very hot material in starting combustion [1 mark]
and the fact that hydrogen could not escape [1 mark]
[3 marks]

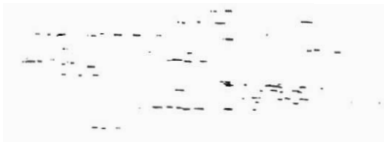
(ii) $\Delta H^{\ominus} = 2\Delta H_f^{\ominus}$ (NaOH) $- 2\Delta H_f^{\ominus}$ (H_2O) [1 mark]
$= -368$ kJ [1 mark]
[2 marks]

(b) (i) Diagram to show correct polarity of water molecule [1 mark]
Correctly assigned interaction with cation and anion [1 mark]
[2 marks]

(ii) More negative value means stronger bonding between cations and water molecules [1 mark]
Stronger bonding arises with higher ionic charge [1 mark]
and smaller ionic radius [1 mark]
Correct comparison of Mg^{2+} and Na^+ in terms of charge and size [1 mark]
Reference to greater number of water molecules bonded to Mg^{2+} than to Na^+ [1 mark]
Quality of written communication: a minimum of 2 linked sentences, presenting a logical argument in which scientific terms such as, *ion, charge, ionic radius* and *hydration*, are used correctly [1 mark]
[6 marks]

(iii) Lattice enthalpy **[1 mark]**

(c) (i) 1 mol of $Mg(OH)_2$ produces 3 mol of ions compared with 2 mol of ions from NaOH [1 mark]
More disorder is associated with 3 mol of dissolved ions than with 2 mol
Or there are more ways of arranging 3 mol of ions than 2 mol [1 mark]
Entropy increases with disorder (*or* with number of arrangements) [1 mark]
[3 marks]



(ii) More water molecules become attached to Mg^{2+} than to Na^{+} [1 mark]
resulting in fewer free water molecules (or causing a greater loss of disorder or smaller increase in disorder) [1 mark]
[2 marks]

(iii) Entropy change in the surroundings [1 mark]
Resulting from heating or cooling by the reaction [1 mark]
[2 marks]
Total 21 marks

3 (a) (i) High pressure [1 mark]
High temperature [1 mark]
[2 marks]

(ii) Higher pressure pushes the molecules closer together [1 mark]
leading to more frequent collisions [1 mark]
Higher temperature gives a larger percentage of collisions/molecules [1 mark]
with energy in excess of the activation enthalpy for the reaction [1 mark]
[4 marks]

(b) *7 marks for 7 of the following eight points:*

For **Reaction 3.1**, equal numbers of molecules on each side of equation, so pressure has no effect on the yield at equilibrium [1 mark]

Reaction is endothermic, so increase in temperature causes position of equilibrium to move to right to oppose temperature increase [1 mark]

so high temperature used to increase yield of products [1 mark]

High temperatures are expensive, so optimum temperature chosen [1 mark]

Reaction 3.2 leads to a reduction in the number of molecules [1 mark]

so high pressure causes position of equilibrium to move to right to oppose the pressure increase [1 mark]

Reaction is exothermic, so increase in temperature causes postion of equilibrium to move to left to oppose temperature increase [1 mark]

and optimum temperature chosen to give reasonable rate [1 mark]

Quality of written communication: a series of more than 2 linked sentences, presenting a clear and logical argument in which scientific terms such as, yield, rate, equilibrium, temperature and pressure, are used correctly [1 mark]
[8 marks]

(c) (i) $K_p = \frac{P_{CH_3OCH_3} \times P_{H_2O}}{(P_{CH_3OH})^2}$

correct partial pressures including squared quantity [1 mark]

correct way up [1 mark]

[2 marks]

(ii) At equilibrium, partial pressure of CH_3OCH_3 equals that of H_2O [1 mark]

(Partial pressure of $CH_3OCH_3)^2$ = 9.00 x $(0.142)^2$ [1 mark]

Partial pressure of CH_3OCH_3 = 0.426 atm [1 mark]

[3 marks]

(d) (i) *Three marks for 3 of the following five points:*

Atoms can be arranged in chains or rings

Molecules can contain double bonds or benzene rings

Chain isomerism can occur

Geometric / *cis-trans* isomerism can occur

Optical isomers can exist **[3 marks]**

(ii) Name *or* description of process [1 mark]

description of use [1 mark]

(for example, cracking of hydrocarbons; acts as a catalyst and/or as a molecular sieve)

[2 marks]

Total 24 marks

4 (a) (i) **Reagent:** chlorine [1 mark]

Conditions: aluminium chloride (*or* $FeCl_3$ or ICl_3) [1 mark]

Anhydrous *(must be stated as condition or in name of substance)* [1 mark]

(Allow aluminium chloride as reagent or catalyst; allow formula) **[3 marks]**

(ii) Catalyst polarises [1 mark]

chlorine molecules to produce positively charged Cl

(either δ+ on molecule or whole + ion) [1 mark]

which are attacked by electrons [1 mark]

of benzene ring.

(Allow 'react with' or 'act as electrophile', but not 'attract' in place of 'attack') **[3 marks]**

(b) Shake the water sample containing the herbicides with ethyl ethanoate (*or* other extracting solvent) [1 mark]

Use large volume of water to small volume of organic solvent [1 mark]

Retain upper layer [1 mark]

Use of separating funnel [1 mark]

Evaporate organic layer to concentrate [1 mark]

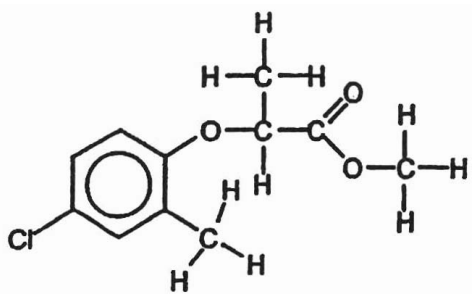
[5 marks]

(c) **(i)** Ester will have lower boiling point/be more volatile than the acid [1 mark]

and so will have a shorter retention time on the column (*or* produce a sharper peak) [1 mark]

[2 marks]

(ii)



correct stucture of methyl ester [1 mark]

rest of molecule [1 mark]

[2 marks]

Total 15 marks

5 **(a)** **(i)** Step 1: R-CHO with CN^-/OH^- [1 mark]

Step 2: RCN with H^+/H_2O [1 mark]

In this case, R = CH_3 [1 mark]

(If no conditions given over arrows, allow one out of two marks for steps 1 and 2; allow 1 mark if step 2 correctly gives final product but step 1 is wrong)

Asterisk on –*CN and –*COOH groups [1 mark]

[4 marks]

(ii) Nucleophilic [1 mark]

addition *(allow ecf)* [1 mark]

[2 marks]

(b) (i) Correct wave number of peak chosen (even if second mark lost) [1 mark]

Bond chosen that gives a peak which would indicate that 2-hydroxypropanaoic acid had formed (so, –OH must be chosen if starting material contains –C=O) [1 mark]

(Mark consequentially, so if starting material is R–Br, a mark could be gained by chosing –C=O) **[2 marks]**

(ii) Two marks for indicating the general point that both compounds [1 mark]

will have similar spectra *(or equivalent; for example,* starting material has same peaks as product) [1 mark]

specifying a peak for which there would be overlap [1 mark]

(Mark consequentially. Therefore, for the correct reaction sequence, the mark is gained for the –C=O peak; if the sequence starts with an –OH compound, the mark would be gained by the –OH peak, etc.) **[3 marks]**

(c) (i) Chemical shift: 9.5 [1 mark]

Type of proton: H in –CHO [1 mark]

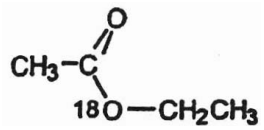
(or chemical shift of 2.3 from $CH_3C{=}O$) **[2 marks]**

(ii) Arises from 3 protons [1 mark]

whereas other peaks from single protons [1 mark]

[2 marks]

(d)



[1 mark]

If label in acid product, the O–CH_2 bond must have broken [1 mark]

If label in alcohol product, the C–O bond must have broken [1 mark]

[3 marks]

Total 18 marks

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6 (a) Molecular mass of correct compound must be calculated with at least one other to provide check [1 mark]

(Values are $C_8H_{10}O = 122.075$, $C_7H_6O_2 = 122.038$, $C_9H_{14} = 122.112$)

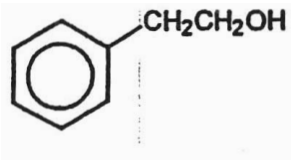
Comment that $C_8H_{10}O$ is Compound Y because its mass is closest to mass spectrum value [1 mark]

[2 marks]

(b) **Name:** 2-phenylethanol *(or satisfactory alternative containing number 2)* [1 mark]

(Score 1 mark for correct name of incorrect structure)

Structure:



[1 mark]

(Score 1 mark if incorrect structure fits the molecular formula $C_8H_{10}O$ and is a stable compound)

Reasoning:

The i.r. spectrum shows no C=O absorption around 1700 cm^{-1} [1 mark]

but shows strong –OH absorption, broad peak at about 3450 cm^{-1} [1 mark]

[4 marks]

(c) **Reagents:** Ethanol (*or* formula)

Conditions: Heat (under reflux) [1 mark]

with conc sulphuric acid [1 mark]

[2 marks]

(d) There needs to be a large hydrocarbon unit capable of adopting a shape like a hexagonal ring [1 mark]

Also, a short side-chain containing an electronegative atom such as oxygen (or a $–CH_2O–$ side-chain) [1 mark]

[2 marks]

(e) *Either:*

It would have a floral smell because a hexagonal ring plus a short side-chain and electronegative atom are present

or

It would not have a floral smell because there is no $-CH_2O-$ side-chain

(i.e. pointing out a structural difference and making a decision about smell from it) **[2 marks]**

Total 12 marks

7 (a) (i) $pH = -\log_{10}[H^+]$ **[1 mark]**

($\log_{10}$ may be replaced by lg or log; $[H^+]$ my be replaced by $[H_3O^+]$) **[1 mark]**

(ii) $$\frac{[H^+(aq)] \times [HCO_3^-(aq)]}{[CO_2(aq)]}$$

top line correct **[1 mark]**

whole expression **[1 mark]**

[2 marks]

(b) (i) $[H^+] = (1.25\times10^{-3}\ mol\ dm^{-3}) \times (4.5\times10^{-7}\ mol\ dm^{-3}) / 2.5\times10^{-2}\ mol\ dm^{-3}$ **[1 mark]**

$= 2.3 \times 10^{-8}\ mol\ dm^{-3}$ **[1 mark]**

[2 marks]

(ii) pH = 7.6 **[1 mark]**

(c) On addition of small amounts of H^+ ions, react with HCO_3^- ions to form CO_2 and H_2O **[1 mark]**

Large excess of HCO_3^- ions **[1 mark]**

On addition of small amounts OH^- ions, react with H^+ ions to form H_2O **[1 mark]**

More CO_2 and H_2O react to replace H^+ ions removed **[1 mark]**

Quality of written communication: a minimum of 2 linked sentences, presenting a logical explanation based on Equation 7.1 which shows that the meaning of the term 'buffer' is understood **[1 mark]**

[5 marks]

(d) $HCO_3^-(aq) \rightleftharpoons H^+(aq) + CO_3^{2-}(aq)$ [1 mark]

$Ca^{2+}(aq) + CO_3^{2-}(aq) \rightleftharpoons CaCO_3(s)$ [1 mark]

[2 marks]

Total 13 marks