

Section 1		Section 2			Section 3			Totals		
Mark	Out of	Q	Mark	Out of	Q	Mark	Out of		Mark	Out of
	25	26	JPT	6	38	MM	13	Section 1		50
		27	JPT	3	39	DGM	20	Section 2		70
		28	JPT	6	40	RC	21	Section 3		80
		29	JPT	6	41	MM	15	Total		200
		30	JPT	6	42	MM	11			
		31	JPT	8				<b>Total</b>		<b>%</b>
		32	DGM	10				MM = 39 JPT = 35 RC = 38 DGM = 38		
		33	DGM	5						
		34	DGM	3						
		35	RC	7						
		36	RC	6						
		37	RC	4						
		<b>Total</b>		70	<b>Total</b>		80			

### MULTIPLE CHOICE ANSWERS

- |       |       |
|-------|-------|
| 1. A  | 14. C |
| 2. A  | 15. A |
| 3. B  | 16. C |
| 4. C  | 17. A |
| 5. D  | 18. D |
| 6. B  | 19. D |
| 7. C  | 20. D |
| 8. D  | 21. C |
| 9. A  | 22. C |
| 10. A | 23. B |
| 11. D | 24. C |
| 12. D | 25. D |
| 13. A |       |

**Section 2: Short Answer****35% [70 marks]**

This section has **12** questions. Answer all questions. Write your answers in the space provided.

Spare pages are included at the end of this booklet. They can be used for planning your responses and/or as additional space if required to continue an answer.

- Planning: If you use the spare pages for planning, indicate this clearly at the top of the page
- Continuing an answer. If you need to use the space to continue an answer, indicate in the original answer space where the answer is continued, i.e. give the page number. Fill in the number of the question(s) that you are continuing to answer at the top of the page.

Suggested working time for this section is 60 minutes.

---

**Question 26****[6 marks]**

Write equations for the reaction that occurs in each of the following procedures.  
If no reaction occurs, write 'no reaction'.

In each case describe what you would observe, including any

- colour change
- odour
- precipitate (give the colour)
- Gas evolutions (state the colour or describe as colourless)

If a reaction occurs but the change is not observable, you should state this.

(a) 1 mol L<sup>-1</sup> iron (III) nitrate solution is added to a 1 mol L<sup>-1</sup> sodium iodide solution.

**[3 marks]**

Equation  $2 \text{Fe}^{3+}(\text{aq}) + 2 \text{I}^{-}(\text{aq}) \rightarrow \text{I}_2(\text{s}) + 2 \text{Fe}^{2+}(\text{aq})$  ✓✓

Observation **a brown solution is added to a colourless solution, the solution turns pale green and a purple solid forms.** ✓  $\text{I}_2(\text{aq})$  accepted

(b) Sodium sulfide solution is added to excess copper (II) chloride solution.

**[3 marks]**

Equation  $\text{S}^{2-}(\text{aq}) + \text{Cu}^{2+}(\text{aq}) \rightarrow \text{CuS}(\text{s})$  ✓

Observation **colourless solution is added to a blue solution, a black precipitate forms, blue solution remains.** ✓✓

**Question 27****[3 marks]**

Butane and propan-1-ol have similar molar masses. Explain, in terms of intermolecular forces, which of the two compounds will have the higher boiling point.

**Propan-1-ol will have the higher boiling point. ✓**

**Both molecules have a similar molar mass and hence similar number of electrons thus the dispersion forces in each will be similar. ✓**

**Propan-1-ol, however has hydrogen bonding between molecules which is stronger than the dispersion forces in butane. ✓**

**Question 28****[6 marks]**

(a) What **chemical test** and **observations** could be used to distinguish between the following:

(i) methylpropan-2-ol and propanoic acid. **[3 marks]**

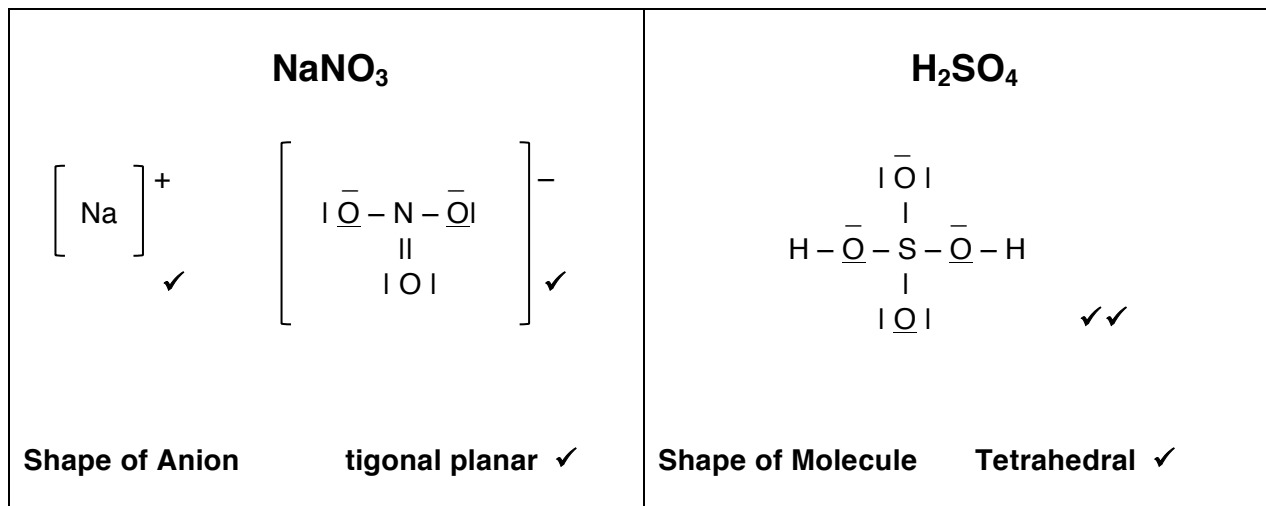
Test:	<b>Add solid sodium carbonate</b>	✓
Observation with methylpropan-2-ol	<b>NVR</b>	✓
Observation with propanoic acid	<b>white solid dissolve, c/ gas evolved</b>	✓

(ii) Zinc and Chromium **[3 marks]**

Test:	<b>Add hydrochloric acid</b>	✓
Observation with Zn:	<b>silver metal dissolves, c/o gas evolves, <u>colourless</u> solution</b>	✓
Observation with Cr	<b>silver metal dissolves, c/o gas evolves, <u>green</u> solution</b>	✓

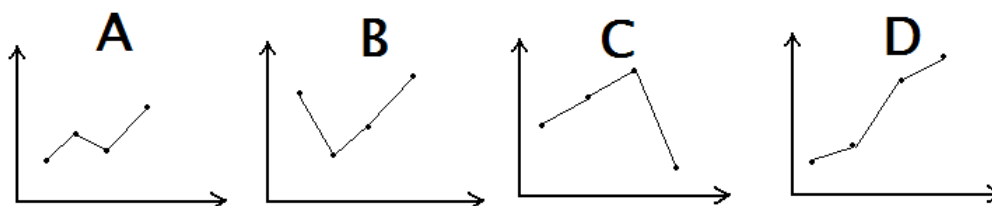
**Question 29****[6 marks]**

Draw electron-dot diagrams showing the arrangement of all valence electrons in the following chemical species. Describe the shape of each (eg: linear/bent/etc)

**Question 30****[6 marks]**

(a) For each of the unlabelled graphs below select which one best represents the expected plots for: [3 marks]

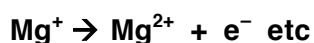
- (i) The boiling points of the hydrides of group 16. **B** ✓
- (ii) The melting points of elements with Atomic numbers 12, 13, 14, 15. **C** ✓
- (iii) The first four successive Ionisation Energy values for a group 2 element. **D** ✓



(b) Explain your choice for (iii). [3 marks]

**I.E is the energy required to remove an electron from the atom in the gaseous phase.** ✓

**There is a steady increase in I.E with each successive IE, since each successive electron is being removed from an increasingly positive ion which requires more energy e.g** ✓

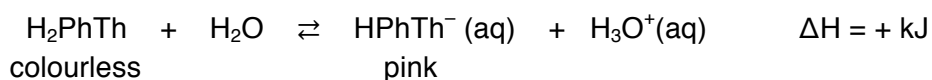


**There is a large increase from the 2<sup>nd</sup> IE to the 3<sup>rd</sup> IE as the third electron is removed from an energy level closer to the nucleus (Mg, 2, 8, 2), hence much more energy is required to remove an electron from one energy level to the next than within an energy level. ✓**

**Question 31****[8 marks]**

Phenolphthalein is a diprotic acid molecule and has two different equilibrium situations which are sensitive to concentrations of OH<sup>-</sup> (aq). In pH range less than or equal to 8.3 the fully hydrogenated form is in such high concentrations and there is no evidence of the first ionisation step forming H<sub>3</sub>O<sup>+</sup>(aq) and a pink coloured ion.

If the phenolphthalein molecule is written as H<sub>2</sub>PhTh, then the equilibrium equation for the hydrolysis of phenolphthalein could be written as



- (a) From the information given above, is the K value for the equation as written going to be high or low? Explain your answer. [2 marks]

**Low, ✓**

**since  $K = \frac{[\text{Products}]}{[\text{Reactants}]}$  and the solution is colourless, therefore  $[\text{reactants}] \gg [\text{products}]$ , hence K is low. ✓**

- (b) The following changes are imposed on a solution of phenolphthalein at equilibrium. Each change is made to a separate test tube and equilibrium is re-established. Complete the table below, indicating the effect on the concentration of HPhTh<sup>-</sup>(aq) and the value of K. Use terms 'increase', 'decrease' or 'no change'.

Also describe what you would observe as equilibrium is re-established in the system.

[6 marks]

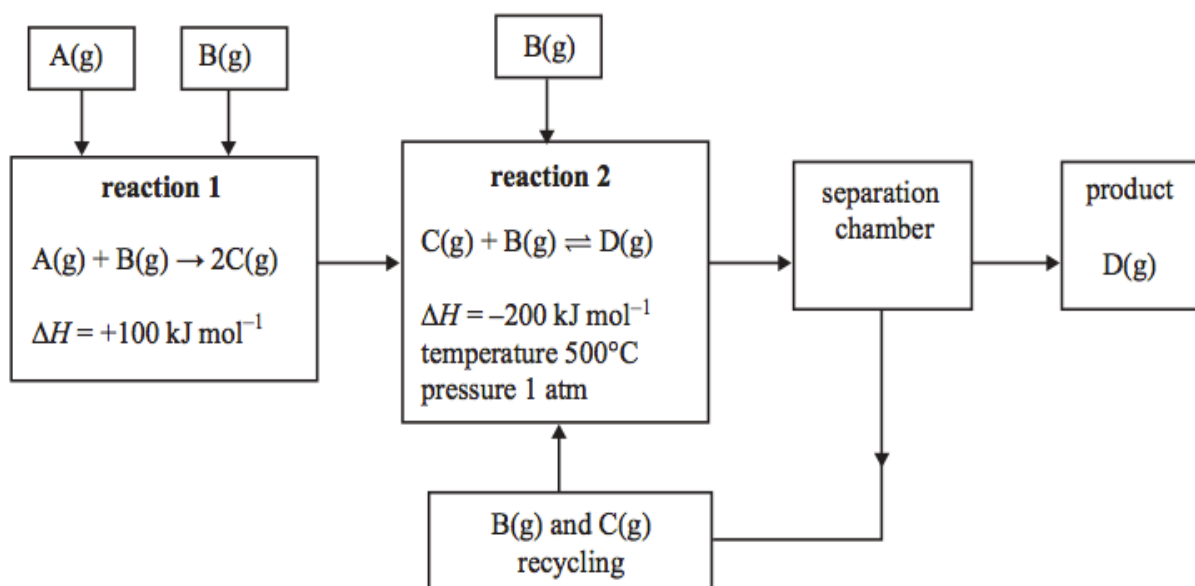
Imposed change	Effect on [HPhTh <sup>-</sup> ] (aq)	Effect on K	Observation
HCl(g) is bubbled through the solution	<b>Decrease ✓</b>	<b>No change ✓</b>	<b>No change (colourless) ✓</b>
The solution is heated	<b>Increase ✓</b>	<b>Increase ✓</b>	<b>Colourless → pink ✓</b>

**Question 32****[10 marks]**

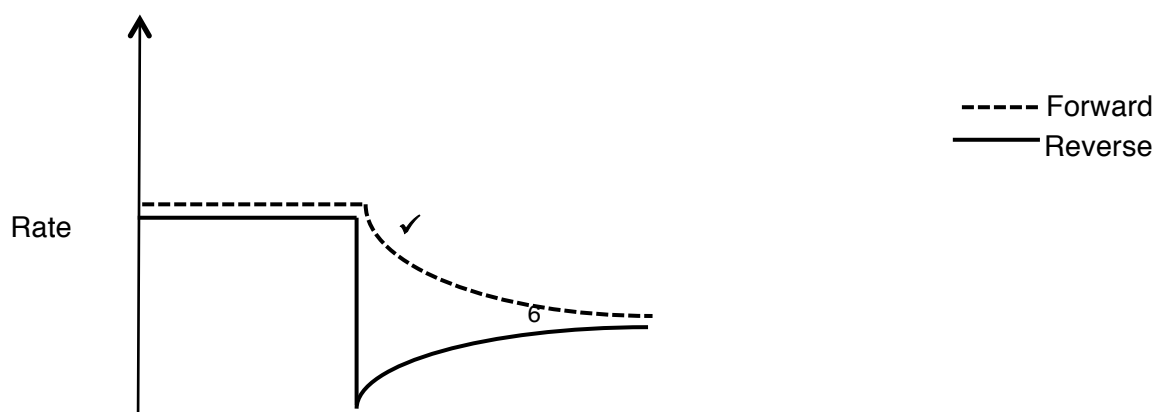
A particular industrial process involves the steps shown on the diagram.

Reaction 1 proceeds to completion but reaction 2 reaches equilibrium and has a high Activation energy.

The product of the industrial process, **D**, passes through a membrane in the separation chamber which is impermeable (resistant) to **B** and **C**.



- (a) D is removed from the system in the separation chamber at  $t_1$ .
- (i) Sketch graphs on the axes below showing how this affect the rates of the forward and reverse reactions. Continue your graph until equilibrium has been re-established at  $t_2$ . [3 marks]



✓

✓

 $t_1$  $t_2$ 

Time

(ii) Explain the changes in rates for the forward and reverse reactions.[4 marks]

**The rates depend on the concentration of reactants and products, the higher the concentration, the greater number of collisions and hence the greater rate.**

**With the removal of D(g), the [products] decreases and hence the reverse rate of reaction decreases. ✓**

**Equilibrium shifts right and so as the forward reaction proceeds, the rate of the forward reaction decreases as the [reactant] decreases. ✓**

**As more products are formed, the [products] increases and hence the rate of the reverse reaction increases again ✓**

**The rates of forward and reverse are equal at  $t_2$ , the new equilibrium. ✓**

(b) In practice the industrial process gives a poor yield of product **D**. As the equilibrium mixture of reaction 2 moves into the separation chamber, what changes would you make to the conditions to increase the yield of **D**?

(No explanations are required)

[3 marks]

**Increase pressure ✓**

**Decrease Temperature ✓**

**Remove products ✓ (add more reactants)**

**Adding more B / reactants or removing D also accepted**

**Question 33****[5 marks]**

What is the pH of a mixture resulting from the addition of 500 ml of  $0.10 \text{ molL}^{-1}$  NaOH and 750 ml of  $0.050 \text{ molL}^{-1}$  HCl?

$$\left. \begin{array}{l} n(\text{NaOH}) = 0.1 \times 0.5 = 0.05 \\ n(\text{HCl}) = 0.05 \times 0.750 = 0.0375 \end{array} \right\} \checkmark$$

Since they react in 1:1 ratio, HCl is LR.

$$n(\text{OH}^-) \text{ unreacted} = 0.05 - 0.0375 = 0.0125 \checkmark$$

$$[\text{OH}^-] = 0.0125 / (0.5 + 0.75) = 0.01 \checkmark$$

$$[\text{H}^+] = 10^{-14} / [\text{OH}^-] = 10^{-12} \checkmark$$

$$\text{pH} = -\log[\text{H}^+] = 12 \checkmark$$

**Question 34****[3 marks]**

The hydrogen phosphate ion,  $\text{HPO}_4^{2-}(\text{aq})$ , is an unusual ion in that it can stabilise solutions by reacting with both small acid changes and small alkaline changes and help keep the pH at a near neutral position.

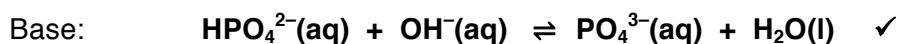
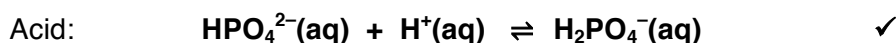
(a) What is the term used to describe this action of the hydrogen phosphate ion?

[1 mark]

**BUFFER** ✓

(b) Write equations showing how this ion responds to a small addition of an acid and a base.

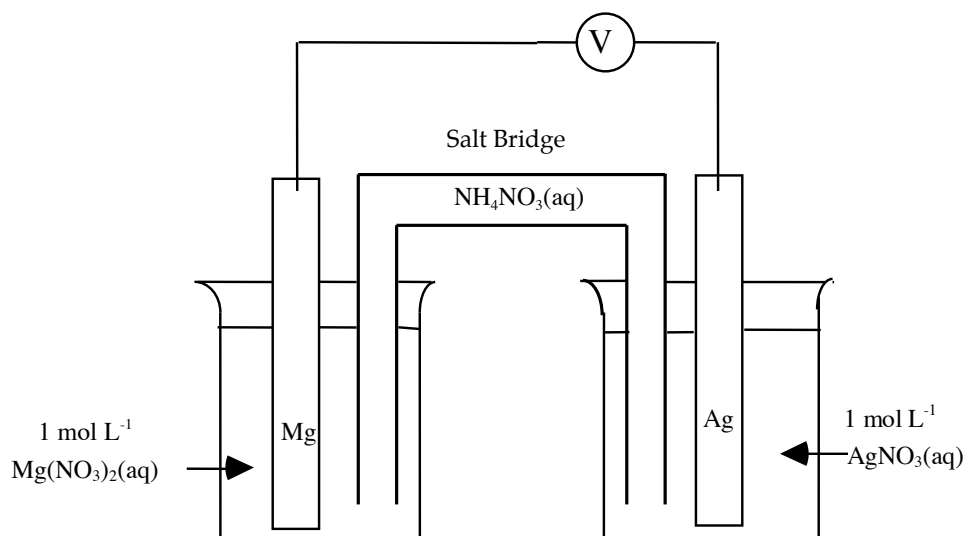
[2 marks]



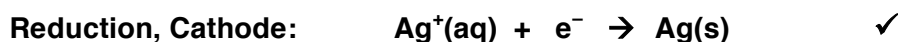


**Question 35****[7 marks]**

Consider the electrochemical below:



- (a) Write the half-equation for the reaction which occurs at the positive electrode. [1 mark]



- (b) Write the equation for the overall redox equation in the cell. [1 mark]



- (c) Calculate the EMF (voltage) of the cell at standard conditions. [1 mark]

**$\text{EMF} = E^\circ(\text{red}) - E^\circ(\text{ox}) = 0.8 - (-2.37) = 3.17 \text{ V}$  ✓**

- (d) Both the anode and cathode have a mass of 5.00 g before they are connected in the cell. The electrodes are connected for 10 minutes and one of the electrodes was found to have a mass of 7.50 g when reweighed. What is the mass of the other electrode after this time?

**[4 marks]**

**Cathode has increased in mass,  $m(\text{Ag})$  deposited = 2.50 g**

**$n(\text{Ag}) = 2.50 / 107.9 = 0.02317$  ✓**

**$n(\text{Mg}) \text{ oxidized} = \frac{1}{2} n(\text{Ag}) = 0.01158$  ✓**

**$m(\text{Mg}) \text{ oxidized} = 0.01158 \times 24.31 = 0.2816 \text{ g}$  ✓**

**$\text{mass of anode} = 5.0 - 0.2816 = 4.72 \text{ g}$  ✓**



**Question 36****[6 marks]**

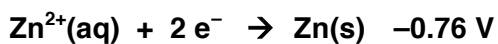
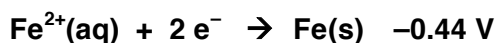
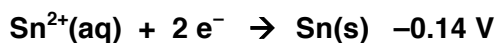
Iron is often coated with other metals to prevent corrosion. "Tin cans" are iron coated with tin and "galvanized iron roofing steel" is iron coated with zinc.

What will happen to the iron when, after a period of time, the tin can and roofing steel are scratched so that the iron is exposed to the moist atmosphere? Using  $E^0$  values explain your observations.

**In the tin can the iron will be oxidized, ✓**

**in the roofing steel the iron is protected from corrosion. ✓**

**When the surfaces are scratched an electrochemical cell ✓ is set up and the more reactive metal oxidises, i.e. the one with the more negative  $E^0$  oxidises and becomes the anode. ✓**

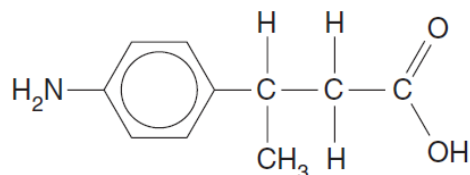


**Tin can: the iron becomes the anode and hence oxidation is accelerated. ✓**

**Roofing Steel: the zinc becomes the anode and is oxidised and the iron becomes the cathode, the site of reduction and hence the iron cannot corrode. ✓**

**Question 37****[4 marks]**

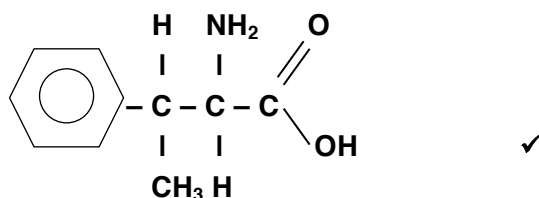
Below is a newly developed amino acid that has the potential for development of an anti-inflammatory drug.



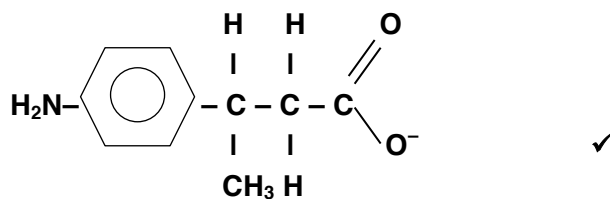
- (a) Explain why it is considered to be an amino acid? [1 mark]

**It contains both an amine,  $-\text{NH}_2$ , and a carboxylic acid group  $-\text{COOH}$  ✓**

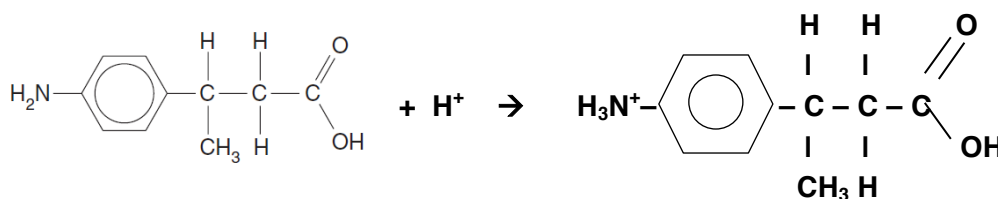
- (b) The molecule above is not an  $\alpha$ -amino acid. In the space below draw the molecule as an  $\alpha$ -amino acid. [1 mark]



- (c) (i) Draw the structural formula of the conjugate base of the original amino acid. [1 mark]



- (ii) Complete the reaction below to show what happens when hydrochloric acid is added to the amino acid. [1 mark]



**END OF SECTION TWO**



**Section 3: Extended answer  
Marks]****40% [80**

This section contains **five** questions. You must answer **all** questions. Write your answers in the spaces provided.

Spare pages are included at the end of the booklet. They can be used for planning your responses and/ or as additional space if required to continue an answer.

- Planning: If you use the spare pages for planning, indicate this clearly at the top of the page.
- Continuing an answer: If you need the space to continue an answer, indicate in the original answer space where the answer is continued, i.e. give the page number. Fill in the number of the question(s) that you are continuing to answer at the top of the page.

Suggested working time for this section is 70 minutes.

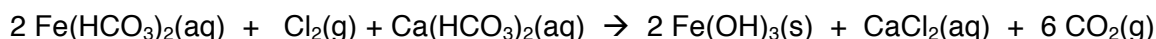
---

**Question 38****[13 marks]**

Ground water contains a number of impurities that must be removed during treatment for it to be suitable for drinking. Soluble iron (II) and manganese (II) compounds are often found in ground water. Although they are not toxic they do contribute to unpleasant odours, taste and colour.

One method of the removal of iron (II), in the form of iron (II) hydrogencarbonate, is to add chlorine and calcium hydrogencarbonate. This causes the iron (II) to oxidise to iron (III) hydroxide which precipitates out and can be filtered off. The other products are calcium chloride and carbon dioxide.

The balanced equation for the reaction is:



- (a) Predict the observations for this reaction. [3 marks]

**Colourless solution and green gas are added to a pale green solution, c/o gas is evolved, brown ppt forms and solution remains colourless.**

**Minimum of 3 out of the 4 required for 3 marks**

A 1000.0 kg sample of ground water containing 45.6 ppm (mg solute/kg solution) of iron (II) hydrogencarbonate is treated by the addition of 3.22 L of chlorine gas at 25°C and 103.2 kPa and excess calcium hydrogencarbonate.

- (b) Determine the limiting reagent of this reaction. [5 marks]

$$n(\text{Cl}_2) = \frac{PV}{RT} = \frac{103.2 \times 3.22}{8.315 \times 298.1} = 0.134 \quad \checkmark$$

$$\text{mass Fe}(\text{HCO}_3)_2 = 45.6 \times 1000 = 45600 \text{ mg} = 45.6 \text{ g} \quad \checkmark$$

$$n\{\text{Fe}(\text{HCO}_3)_2\} = \frac{45.6}{177.9} = 0.256 \quad \checkmark$$

$$n(\text{Cl}_2) \text{ required} = \frac{1}{2} n\{\text{Fe}(\text{HCO}_3)_2\} = 0.128 \quad \checkmark$$

hence plenty of  $\text{Cl}_2$  available and  $\text{Fe}(\text{HCO}_3)_2$  in LR  $\checkmark$

or  $n\{\text{Fe}(\text{HCO}_3)_2\} \text{ needed} = 2 n(\text{Cl}_2) = 2 \times 0.134 = 0.268.$

**Not enough  $\text{Fe}(\text{HCO}_3)_2$  present for all the chlorine to react.**

- (c) Calculate the mass of iron (III) hydroxide that is produced in this reaction. [2 marks]

$$n(\text{Fe}(\text{OH})_3) = \text{Fe}(\text{HCO}_3)_2 = 0.256 \quad \checkmark$$

$$m(\text{Fe}(\text{OH})_3) = 0.256 \times 106.874$$

$$= \underline{27.4 \text{ g}} \quad \checkmark$$

- (d) Calculate the mass of excess reagent remaining at the end of the reaction. [3 marks]

$$\begin{aligned} n(\text{Cl}_2) \text{ unreacted} &= 0.134 - 0.128 && \checkmark \checkmark \\ &= 0.006 \end{aligned}$$

$$\begin{aligned} m(\text{Cl}_2) \text{ unreacted} &= 0.006 \times 70.9 \\ &= \underline{0.425 \text{ g}} && \checkmark \end{aligned}$$

**Question 39****[20 marks]**

You have been given a bottle of wine for testing the acid content and a standardised sodium hydroxide solution. Assume that the acid is present as tartaric acid, a diprotic weak acid. You place the standard solution in the burette.

- (a) For the equipment listed below, indicate what each should be rinsed with. [4 marks]

Equipment	Rinsed with
Stock bottle to store NaOH solution	<b>NaOH ✓</b>
Conical flask	<b>Distilled water ✓</b>
Pipette	<b>Wine ✓</b>
Burette	<b>NaOH ✓</b>

- (b) Which of these two given indicators would be an appropriate indicator for this titration? Explain your choice. [3 marks]

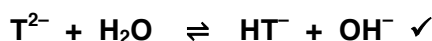
Thymol blue: endpoint range 8.0 – 9.6 colours: yellow (acidic) – blue (basic)

Bromophenol blue: endpoint range 3.0 – 4.6 colours: yellow (acidic) – violet (basic)

Indicator choice: **THYMOL BLUE ✓**

Explanation:  $\text{H}_2\text{T} + 2 \text{NaOH} \rightarrow 2 \text{H}_2\text{O} + 2\text{Na}^+ + \text{T}^{2-}$  ( $\text{H}_2\text{T}$  = tartaric acid)

**The anion of the weak acid,  $\text{T}^{2-}$ , hydrolyses to form a basic solution due to the presence of hydroxide ions:**



**Need an indicator which changes colour at  $\text{pH} > 7$  ✓**

- (c) The sodium hydroxide needed to be standardised before it can be titrated with the wine since it cannot be used as a primary standard. [4 marks]

List 3 characteristics that make a substance suitable to be used as primary standard?

- **Stable (e.g does not react with  $\text{CO}_2$  from the atmosphere / gain or lose water from the atmosphere / oxidise or reduce substances in its surrounding) ✓**
- **High molar mass ✓**
- **High known purity ✓**

Why is sodium hydroxide unsuitable as a primary standard?

**NaOH is deliquescent – it absorbs moisture and  $\text{CO}_2$  from the atmosphere and hence is not stable during weighting. ✓**



- (d) The wine was diluted before it was titrated with the NaOH solution. 10 mL of wine was added to 100 mL volumetric flask and the solution made up to 100 mL. 25.0 mL aliquots of the diluted wine were then titrated against the standard 0.102 mol L<sup>-1</sup> NaOH solution. The burette readings are as follows:

	1	2	3	4
Final volume, mL	22.56	43.22	22.02	42.73
Initial volume, mL	2.11	22.56	1.40	22.02
Titre used, mL	<b>20.45</b>	<b>20.66</b>	<b>20.62</b>	<b>20.71</b>

- (i) Complete the table and calculate the average titre. [2 marks]

✓ for table, average titre =  $(20.66 + 20.62 + 20.71) / 3 = \underline{20.66 \text{ mL}}$  ✓

- (ii) Calculate the concentration in mol L<sup>-1</sup> of the tartaric acid in [4 marks]
- the diluted wine and then in
  - the original wine.

$$n(\text{NaOH}) = 0.102 \times 0.02066 = 2.107 \times 10^{-3} \quad \checkmark$$

$$n(\text{acid, H}_2\text{T}) = \frac{1}{2} n(\text{NaOH}) = 1.054 \times 10^{-3} \quad \checkmark$$

$$[\text{acid}] \text{ diluted wine} = \frac{1.054 \times 10^{-3}}{0.025} = \underline{0.0421 \text{ mol L}^{-1}} \quad \checkmark$$

$$[\text{acid}] \text{ undiluted wine} = 0.0421 \times 10 = \underline{0.421 \text{ mol L}^{-1}} \quad \checkmark$$

- (iii) Assuming the density of the wine is 1.05 g mL<sup>-1</sup>, calculate the percentage by mass of the tartaric acid in the wine. [3 marks]  
The molar mass of tartaric acid is 150.0 g mol<sup>-1</sup>.

$$m(\text{acid}) \text{ in } 1 \text{ L} = n \times M = 0.421 \times 150 = 63.15 \text{ g} \quad \checkmark$$

$$\text{mass of } 1 \text{ L wine} = 1050 \text{ g} \quad \checkmark$$

$$\% \text{ acid in wine} = \frac{63.15}{1050} \times 100 = \underline{6.02 \%} \quad \checkmark$$

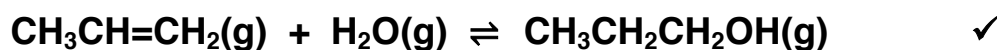
**Question 40****[21 marks]**

Propan-1-ol and propene are extremely useful carbon compounds used in industry to make ropes, carpets, fuel oils etc. The production of propan-1-ol can be achieved two ways:

- the selective addition of water to propene and
- the hydroformylation of ethene to propanal using CO and H<sub>2</sub> and then the hydrogenation of propanal to propan-1-ol.

- (a) Write the equation for the reaction between propene and water to produce propan-1-ol in the presence of phosphoric acid. All reactants and products are in the gas phase.

[1 mark]



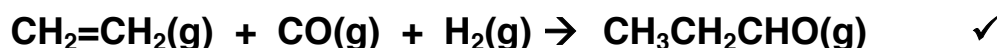
- (b) There is a possibility of another alcohol being formed in (a) above, name this alcohol.

[1 mark]

**Propan-2-ol**                       $\checkmark$

- (c) Write a balanced equation for the reaction between ethene and CO and H<sub>2</sub> to produce propanal.

[1 mark]



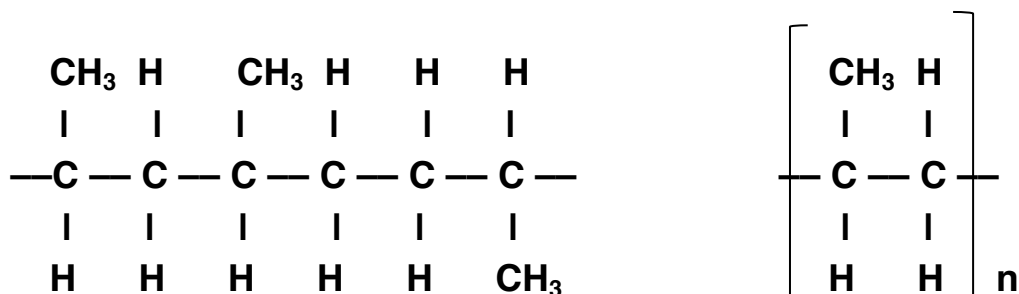
- (d) Write a balanced equation for the reaction between propanal and hydrogen to give propan-1-ol.

[1 mark]



- (e) Propene is used by Shell to make the addition polymer polypropene which is used to make carpets and ropes. Draw a piece of polypropene showing at least three monomer units.

[2 marks]



- (f) If the equilibrium reaction in (a) above is exothermic, explain what conditions of temperature and pressure you would employ to get the optimum yield of propan-1-ol. The phosphoric acid must also be mentioned in your discussion. [7 marks]

**Both high temperature and high pressure will increase the rate of the reaction due to (i) an increase in the frequency of collisions (T and P) and (ii) for T, an increase in the proportion of molecules with energy greater than the Activation Energy.** ✓✓

**Low temperature will increase the yield, since the forward reaction is exothermic equilibrium will shift right to increase the temperature ✓ and hence a compromise for temperature is required.** ✓

**High pressure will increase the yield as equilibrium will shift to the side with the least gaseous molecules (2:1) which is for the forward direction. Hence a high pressure is good for both the rate and yield.** ✓

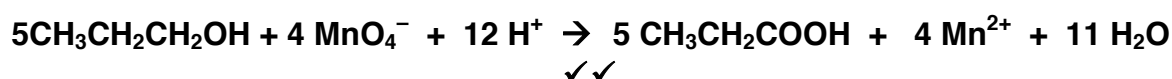
**The phosphoric acid is used as a catalyst to increase the rate of the reaction** ✓

- (g) The propan-1-ol produced can be oxidised with excess acidified potassium permanganate to produce propanoic acid which can then be used in the production of several esters.

Write the two-half equations for the reaction between propan-1-ol and acidified potassium permanganate to make propanoic acid. [5 marks]



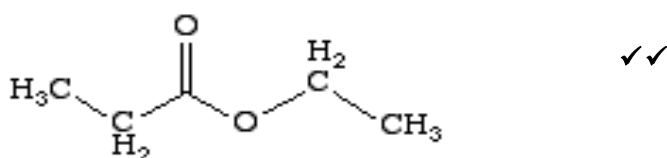
Full Redox reaction:



- (h) The ester ethyl propanoate is used as a fragrance in several products. [3 marks]

What compound must be added to propanoic acid to form this ester? **ETHANOL** ✓

Draw the full structure of this ester.



**Question 41****[15 marks]**

An old drum of pesticide has been found on a farm. Elemental analysis of this pesticide shows the presence of carbon, hydrogen, phosphorus and oxygen. A 5.21 g sample of the pesticide produces

6.32 g of carbon dioxide and 3.23 g of water when combusted completely in excess oxygen.

A second sample, 3.15 g of the pesticide is treated with nitric acid to convert all the phosphorus to phosphate ions. The resulting solution is treated with excess calcium nitrate solution to produce 3.37 g of calcium phosphate.

(a) Determine the empirical formula of the pesticide.

**[11 marks]****5.21g sample:**

$$n(\text{CO}_2) = 0.144$$

$$n(\text{C}) = 0.144 \quad m(\text{C}) = 1.729 \text{ g } \checkmark \quad \% \text{ C} = 33.19\% \checkmark$$

$$n(\text{H}_2\text{O}) = 0.179$$

$$n(\text{H}) = 0.3586 \quad m(\text{H}) = 0.361 \text{ g } \checkmark \quad \% \text{ H} = 6.94\% \checkmark$$

**3.15 g sample**

$$n(\text{Ca}_3(\text{PO}_4)_2) = 3.37 / 310.18 = 0.01086 \checkmark$$

$$n(\text{P}) = 2 \times n(\text{Ca}_3(\text{PO}_4)_2) = 2 \times 0.01086 = 0.0217 \checkmark$$

$$m(\text{P}) = 0.673 \text{ g } \% \text{ P} = 21.4\% \checkmark$$

$$\text{Hence } \% \text{ O} = 100 - \% \text{ P} - \% \text{ C} - \% \text{ H} = 38.6\% \checkmark$$

	C	H	P	O	
%	33.19	6.94	21.4	38.6	
Moles	2.756	6.88	0.691	2.41	✓
Ratio ( $\div 0.691$ )	3.99	9.956	1	3.5	✓
Ratio x 2	8	20	2	7	

**Empirical Formula is:  $\text{C}_8\text{H}_{20}\text{P}_2\text{O}_7$  ✓**

- (b) At 25°C and 110.1 kPa, 1.84 g of this pesticide has a volume 142.7 mL in the gaseous phase. Determine the molar mass of this pesticide. [2 marks]

$$n = \frac{PV}{RT} = \frac{110.1 \times 0.1427}{8.315 \times 298.1} = 6.338 \times 10^{-3} \quad \checkmark$$

$$M = \frac{\text{mass}}{\text{moles}} = \frac{1.84}{6.338 \times 10^{-3}} = 290 \text{ g mol}^{-1} \quad \checkmark$$

- (c) What is the molecular formula of the pesticide? [2 marks]

$$M \text{ of empirical } (\text{C}_8\text{H}_{20}\text{P}_2\text{O}_7) = 290.18$$

**Ratio:**

$$\text{Molecular Mass / Empirical mass} = 290 / 290.18 = 1.00 \quad \checkmark$$

**Hence Molecular Formula is also  $\text{C}_8\text{H}_{20}\text{P}_2\text{O}_7$  ✓**

**Question 42****[11 marks]**

Using Group I elements and Period 3 elements discuss and explain the variation in the following properties of the elements:

- (i) Melting Points [7 marks]  
(ii) Electronegativity [4 marks]

**Melting Points**

**Across the period, Na to Ar** the melting points of the elements increase to Si and then decrease again. M.pt depends on the strength of the bonds being broken during melting.

**Na, Mg, Al** – metallic bonding with a strong force of attraction between the valence electrons and the cation. The m.pt increases from Na to Al since the cationic charge increases,  $\text{Na}^+$ ,  $\text{Mg}^{2+}$ ,  $\text{Al}^{3+}$  hence there is a stronger force of attraction for the valence electrons.

**Silicon** – covalent network with strong covalent bonds to be broken in 3D network, high m.pt .

**P to Cl** ( $\text{P}_4$ ,  $\text{S}_8$ ,  $\text{Cl}_2$ ) – all non-polar covalent molecules with strong covalent bonds between atoms within the molecule (intramolecular bonds) but weak dispersion forces between molecules and it is the dispersion forces which are disrupted during the phase change and hence they have low m.pt.s. ( $\text{S}_8$  will be greater than  $\text{P}_4$  since dispersion forces increases with the number of electrons in a molecule)

**Ar** – gaseous atoms, very weak dispersion forces between atoms.

**Down group I, Lithium to Cesium** the melting points decreases. Metallic bonding - all the cations are + 1, hence the the metallic bond strength depends on the distance of the valence electrons from the nucleus and hence it is weaker as you descend the group.

**Electronegativity** – a measure of the electron attracting power an atom has for the shared pair of electrons in a covalent bond

**Across the period, Na to Ar,** EN increases since the nuclear charge increases and the atomic radius decreases hence there is a stronger force of attracting for the shared pair of electrons. The electrons are all in the same principle energy level and hence shielding is constant. Inert gases are not assigned an EN value as they do not react readily.

**Down group 1, Li to Cs,** EN decreases. Although the nuclear charge increases the shielding effect also increases and negates the increase in nuclear charge and since

**the valence electrons are further from the nucleus the force of attraction for the electrons is weaker.**