YEAR 12 CHEMISTRY 2003

EXAMINATION SOLUTIONS

Part 1: Multiple Choice Section

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

Part 2: Short Answer Section
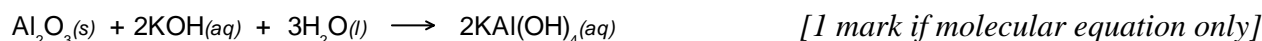
1. (a) $5CH_3CHO_{(l)} + 2MnO_4^-{}_{(aq)} + 6H^+{}_{(aq)} \longrightarrow 5CH_3COOH_{(aq)} + 2Mn^{2+}{}_{(aq)} + 3H_2O_{(l)}$ *[2 marks]*

   When purple solution added to a colourless liquid it goes clear (until when in excess the solution stays pink). A slight vinegar like odour can be detected.
   [1 mark for at least one suitable observation that includes reference to colour]

   (b) $Al_2O_3{}_{(s)} + 2OH^-{}_{(aq)} + 3H_2O_{(l)} \longrightarrow 2Al(OH)_4^-{}_{(aq)}$ *[2 marks]*
   OR
   $Al_2O_3{}_{(s)} + 2KOH_{(aq)} + 3H_2O_{(l)} \longrightarrow 2KAl(OH)_4{}_{(aq)}$ *[1 mark if molecular equation only]*

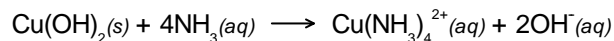   White solid dissolves forming a clear colourless solution.
   [1 mark for at least one suitable observation that includes reference to colour]

   (c) $Cu^{2+}{}_{(aq)} + 2OH^-{}_{(aq)} \longrightarrow Cu(OH)_2{}_{(s)}$ OR $Cu^{2+}{}_{(aq)} + 2NH_3{}_{(aq)} + 2H_2O_{(l)} \longrightarrow Cu(OH)_2{}_{(s)} + 2NH_4^+{}_{(aq)}$
   [1 mark]
   $Cu(OH)_2{}_{(s)} + 4NH_3{}_{(aq)} \longrightarrow Cu(NH_3)_4^{2+}{}_{(aq)} + 2OH^-{}_{(aq)}$ *[1 mark]*

   When a clear solution is added to the blue solution a blue gelatinous precipitate is formed. On further addition of the clear solution the blue precipitate dissolves and a deep royal blue clear solution is formed.
   *[2 marks for at least two suitable observations that include reference to colour]*

   (d) No reaction. Therefore no visible reaction.   *[2 marks]*

2.   *[½ mark each – there may be other relevant answers = 5 marks]*

DESCRIPTION	Formula or Name
A crystalline dicarboxylic acid that is used in acid-base and redox titrations as a primary standard.	HOOCCOOH.$2H_2O$ *or* $H_2C_2O_4$.$2H_2O$ *or* HOOCCOOH *or* $H_2C_2O_4$ oxalic acid
A metal that forms covalent compounds with non-metals.	Be *or* beryllium (not boron because it is non-metallic)
A gas produced in the electrolysis of molten sodium chloride.	Cl_2 (no marks for Cl) *or* chlorine
The monomer used to make polythene tubing.	$CH_2=CH_2$ *or* ethene
An alcohol with three hydroxyl groups.	$CH_2(OH)CH(OH)CH_2(OH)$ *or* 1,2,3-propanetriol *or* propane-1,2,3-triol
A solid covalent substance that conducts electricity.	C *or* graphite
A negatively charged complex ion.	$Al(OH)_4^-$ *or* aluminate ion *or* tetrahydroxoaluminate ion
A gas that when dissolved in water has a bleaching effect.	Cl_2 (no marks for Cl) *or* chlorine
A metal ion that has the electron configuration – $1s^2 2s^2 2p^6 3s^2 3p^6$	K^+ ; Ca^{2+} ; Ga^{3+} *or* potassium; calcium; gallium ions
A polymer that is used to produce pipes for drainage and reticulation of gardens and also to make imitation leather lounge suites.	-(CH_2-CHCl- CH_2-CHCl-)- *or* PVC *or* polyvinylchloride

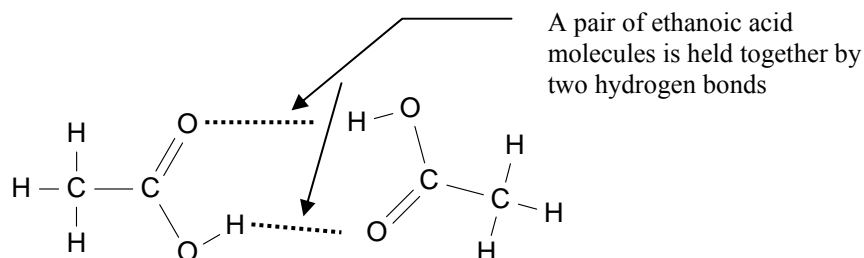3. (a) ethyl 3,5-dichloro-4-ethyl-5-methylhexanoate   *[2 marks]*
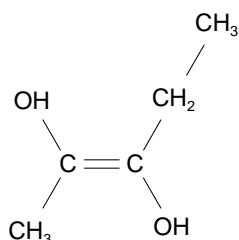
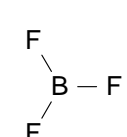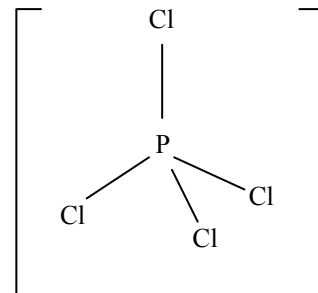   (b)   *[2 marks]*

4. Both have hydrogen bonds (and dispersion forces) between molecules that must be overcome for the substance to boil, BUT carboxylic acids are able to form TWO hydrogen bonds with each other thus requiring more energy to overcome the forces of attraction. Alcohols can only form one hydrogen bond per molecule so less energy is required to overcome the forces of attraction between the molecules.
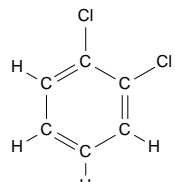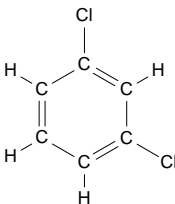
                                                                              [2 marks]
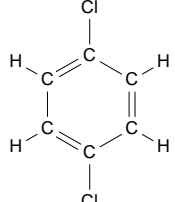
A pair of ethanoic acid molecules is held together by two hydrogen bonds

5.

Species	Electron dot diagram	Shape (sketch or name)
BF_3		trigonal (triangular) planar
CS_2	$S = C = S$ linear	
$PCl_4{}^+$		tetrahedral

[6 marks]

6.

Sketch	Name	Polar/non-polar
	1,2-dichlorobenzene	polar
	1,3-dichlorobenzene	polar
	1,4-dichlorobenzene	non-polar

[9 marks]

7.

$$CH_3 — (CH_2)_{10} — CH_2 —\langle\bigcirc\rangle— SO_3^- \ Na^+$$

[2 marks]

8.

hydroxyl *or* alcohol *or* alkanol group $\longrightarrow$ OH

O — CH_3

CHO $\longleftarrow$ aldehyde *or* carbonyl or alkanal group
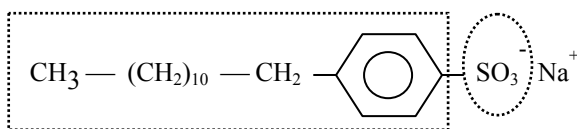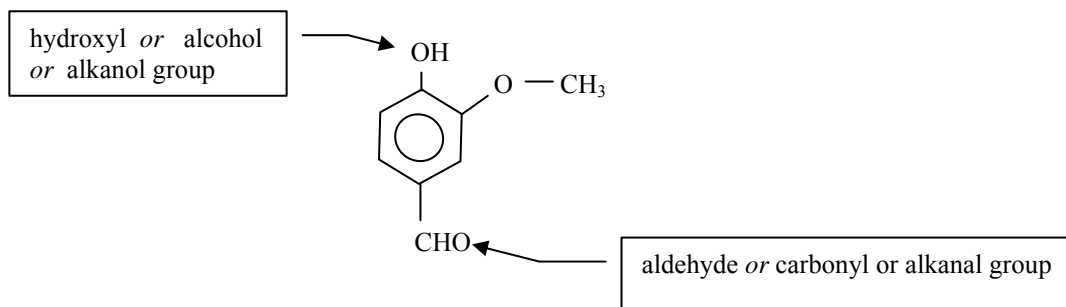
[2 marks]

9. Equilibrium constant expression: $K = \left[Ca^{2+}\right]\left[OH^-\right]^2$ *[2 marks]*

Experiment	How the equilibrium shifts [shifts right, shifts left or no change]	Observations
A small amount of 10 mol L^{-1} HCl was added to flask 1.	*Shifts right*	*Ca(OH)$_2$(s) decreases in mass* or *more of the solid dissolves and less solid remains*
A small amount of concentrated NaOH(aq) was added to flask 2.	*Shifts left*	*Ca(OH)$_2$(s) increases in mass* or *more of the solid forms*
A small volume of gaseous CO$_2$ was bubbled through the solution in flask 3.	*Shifts right*	*Solution turns milky (due to formation of CaCO$_3$(s)) therefore the pile of Ca(OH)$_2$(s) decreases in size.*

[6 marks]

10.

Expt No.	Electrolyte	Electrodes	Half-reactions at:	
			cathode	anode
1	1 mol L^{-1} CuSO$_4$(aq)	carbon	$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$	$2H_2O(l) \rightarrow O_2(g) + 4H^+(aq) + 4e^-$
2	KBr(l)	platinum	$K^+(l) + e^- \rightarrow K(l)$	$2Br^-(l) \rightarrow Br_2(g) + 2e^-$
3	A mixture of 1 mol L^{-1} AgNO$_3$(aq) and 1 mol L^{-1} Cd(NO$_3$)$_2$(aq)	platinum	$Ag^+(aq) + e^- \rightarrow Ag(s)$	$2H_2O(l) \rightarrow O_2(g) + 4H^+(aq) + 4e^-$

[6 marks]

11. (a) NaOH is hygroscopic i.e. it absorbs moisture from the air, thus its weight changes during weighing. Also it absorbs CO_2 from the air as well. Therefore an accurate reading for the mass of NaOH(s) is not possible.

[2 marks]

(b) Phenolphthalein. The reaction between a weak acid and strong base gives an equivalence point which is in the basic range (pH = 9), therefore you require an indicator whose end point (point at which the indicator changes colour) is also in the basic range. Phenolphthalein has a pH range of 8.3 to 10.0. The basic equivalence point is due to the hydrolysis of ethanoate ions that produce basic OH⁻ ions.

$$CH_3COO^-(aq) + H_2O(l) \rightleftharpoons CH_3COOH(aq) + OH^-(aq)$$

[2 marks]

12. (a) Plates 3 and 4 show the least corrosion.
Plate 3 is protected by zinc which acts as a sacrificial anode. The zinc has a greater tendency to lose electrons (stronger reducing agent, more active metal) than iron, therefore it will become the anode of an electrochemical cell and corrodes instead of the iron that becomes the cathode and tends to gain electrons and not corrode.
Plate 4 cannot corrode (lose electrons) because it is continually being supplied with electrons from the battery, so it becomes the cathode of an electrolytic cell. The iron nail (scrap iron) becomes the anode and it loses electrons and corrodes (sacrificial anode).

[1 mark for the two plates and 2 marks for the reasons]

(b) Plates 2 and 5 show the most corrosion.
In Plate 2 the iron acts as a sacrificial anode as it has a greater tendency to lose electrons (stronger reducing agent, more active metal) than tin, therefore the iron is oxidized in preference to the tin.
Plate 5 has accelerated corrosion due to electrons being removed from the iron plate by the positive terminal of the battery. Thus the reaction $Fe \longrightarrow Fe^{2+}(aq) + 2e^-$ is most likely to occur and corrosion results.

[1 mark for the two plates and 2 marks for the reasons]

(c) Plate 1 (the iron has not been treated in any way).

[1 mark for the plate no reason required]

13. (a) Bauxite *[1 mark]*
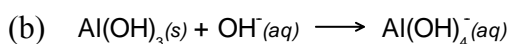
(b) $Al(OH)_3(s) + OH^-(aq) \longrightarrow Al(OH)_4^-(aq)$ *[1 mark]*

(c) Aluminium smelters require a cheap source of electricity and WA has a high tariff due to its high quality coal and natural gas having to be piped from the NW shelf. There is no cheap source like hydroelectricity (in Tasmania) and easily mined brown coal (in Victoria). It is an economic decision rather than a chemical reason.

[1 mark]

Part 3: Calculations Section

1. (a)

$n_{CO_2} = \dfrac{m}{M} = \dfrac{7.678}{44.01} = 0.1745\,mol$

$n_C = 0.1745\,mol$

$m_C = n \times M = 0.1745 \times 12.01 = 2.0953\,g$

$\%_C = \dfrac{2.0953}{3.845} \times \dfrac{100}{1} = 54.49\%\,C$
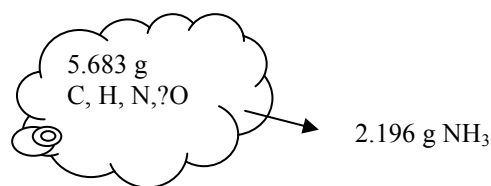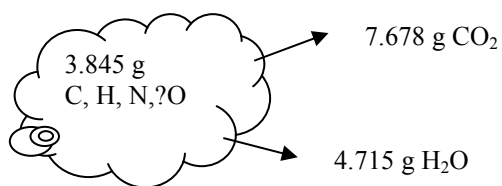
$n_{H_2O} = \dfrac{m}{M} = \dfrac{4.715}{18.016} = 0.2617\,mol$

$n_H = 2 \times 0.2617 = 0.5234\,mol$

$m_H = n \times M = 0.5234 \times 1.008 = 0.5276\,g$

$\%_H = \dfrac{0.5276}{3.845} \times \dfrac{100}{1} = 13.72\%\,H$

$n_{NH_3} = \dfrac{m}{M} = \dfrac{2.196}{17.034} = 0.1289\,mol$

$n_N = 0.1289\,mol$

$m_N = n \times M = 0.1289 \times 14.01 = 1.8061\,g$

$\%_N = \dfrac{1.8061}{5.683} \times \dfrac{100}{1} = 31.78\%\,N$

There is no oxygen present because %C + %H + %N = 54.49 + 13.72 + 31.78 = 99.99%

C	H	N	
54.49 g	13.72 g	31.78 g	Mass in 100g
$\dfrac{54.49}{12.01}$	$\dfrac{13.72}{1.008}$	$\dfrac{31.78}{14.01}$	Divide by M
4.537	13.61	2.268	Moles
2.00	6.00	1.00	Divide by smallest

∴ the <u>empirical formula</u> is **C$_2$H$_6$N**   *[6 marks]*

(b) m = 1.250 g $n = \dfrac{PV}{RT} = \dfrac{103.0 \times 0.343}{8.315 \times 300} = 0.01416\,mol$

        or [use the combined gas law to find the volume at STP, then use n = V ÷ 22.4]

V = 343 mL = 0.343 L $n = \dfrac{m}{M}$ $M = \dfrac{m}{n} = \dfrac{1.250}{0.01416} = 88.28\,g.mol^{-1}$

T = 27°C = 300 K   <u>**Relative Molecular Mass**</u> = **88.28**   *[2 marks]*

P = 103.0 kPa

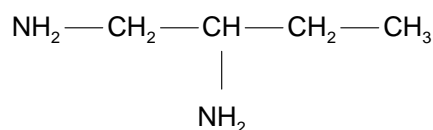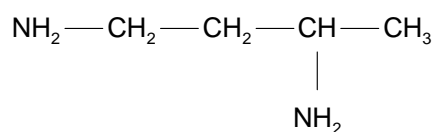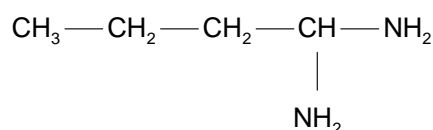(c) Empirical formula: C$_2$H$_6$N has a molar mass of 44.078

    The <u>**molecular formula**</u> is **C$_4$H$_{12}$N$_2$** because it has a molar mass of 88.28 which is twice the molar mass of the empirical formula therefore it must have twice the number of atoms.

                                                       [2 marks]

(d)

| 1,4-diaminobutane (1,4-butanediamine) | NH_2—CH_2—CH_2—CH_2—CH_2—NH_2 |

1,2-diaminobutane
(1,2-butanediamine)

NH_2—CH_2—CH—CH_2—CH_3
                        |
                     NH_2

1,3-diaminobutane
(1,3-butanediamine)

NH_2—CH_2—CH_2—CH—CH_3
                              |
                           NH_2

1,1-diaminobutane
(1,1-butanediamine)

CH_3—CH_2—CH_2—CH—NH_2
                              |
                           NH_2

[Any two of the above or any other suitable answer – 2 marks]

2.   (a) $n(Br_2) = cV = 0.200 \times 0.0250 =$ **5.00 x 10⁻³ mol**   *[1 mark]*

   (b) $S_2O_3^{2-}{}_{(aq)} + 4Br_{2(aq)} + 10OH^-{}_{(aq)} \longrightarrow 2SO_4^{2-}{}_{(aq)} + 8Br^-{}_{(aq)} + 5H_2O_{(l)}$
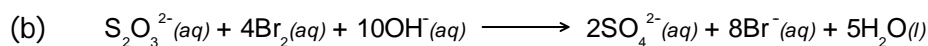
   $n(S_2O_3^{2-}) = cV = 0.0250 \times 10.60 \times 10^{-3} = 2.65 \times 10^{-4}\,mol$ *[1 mark]*

   $n(Br_2) = 4 \times n(S_2O_3^{2-}) = 4 \times 2.65 \times 10^{-4} =$ **1.06 x 10⁻³ mol**   *[1 mark]*

   (c) $n(Br_2)$ that reacted with oil = $n(Br_2)$ initially added - $n(Br_2)$ left over

   $= 5.00 \times 10^{-3} - 1.06 \times 10^{-3}$

   $= 3.94 \times 10^{-3}\,mol$ *[1 mark]*

   $\therefore m(Br_2) = n \times M = 3.94 \times 10^{-3} \times 159.8 = 0.6296g$ *[1 mark]*

   mass in mg = 629.6 mg Br_2 added to 7.75 mL oil   *[1 mark]*

   mass of 7.75 mL oil = D x V = 1.60 g mL⁻¹ x 7.75 mL = 12.4 g   *[1 mark]*

   $\therefore bromine - number = \dfrac{mg(Br_2)}{g(oil)} = \dfrac{629.6}{12.4} =$ **50.8 mg g⁻¹**   *[2 marks]*

3.

1.325 g tablet

...... + 12.07 mL, 1.070 M HCl   (solution 1)

...... +11.74 mL, 0.5310 M NaOH   (solution 2)

...... + 5.12 mL, 1.070 M HCl   (solution 3)

...... + 3.17 mL, 0.5310 M NaOH   (solution 4)

Total number moles of HCl that reacted with tablet $= c_1V_1 + c_3V_3$

$= (1.070 \times 12.07 \times 10^{-3}) + (1.070 \times 5.12 \times 10^{-3}) = 0.01839 \, mol$ *[1 mark]*

Total number moles of NaOH that reacted with tablet $= c_2V_2 + c_4V_4$

$= (0.5310 \times 11.74 \times 10^{-3}) + (0.5310 \times 3.17 \times 10^{-3}) = 7.917 \times 10^{-3} \, mol$ *[1 mark]*

Therefore, n(HCl) that reacted with tablet $= 0.01839 - 7.917 \times 10^{-3} = 0.01047 \, mol$ *[1 mark]*

$$CaCO_3{}_{(s)} + 2HCl_{(aq)} \longrightarrow CaCl_2{}_{(aq)} + H_2O_{(l)} + CO_2{}_{(g)}$$
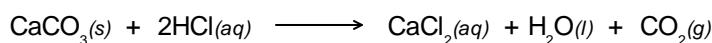
n(HCl) = 0.01047 mol

$n(CaCO_3) = \dfrac{1}{2} \times n(HCl) = \dfrac{1}{2} \times 0.01047 = 5.236 \times 10^{-3} \, mol$ *[2 marks]*

$m(CaCO_3) = n \times M = 5.236 \times 10^{-3} \times 100.09 = 0.5241 g$ *[1 mark]*

Therefore, **% CaCO₃ in tablet** $= \dfrac{m(CaCO_3)}{m(tablet)} \times \dfrac{100}{1} = \dfrac{0.5241}{1.3259} \times \dfrac{100}{1} = \mathbf{39.5\%}$ *[1 mark]*

4.   (a) $Zn_{(s)} \longrightarrow Zn^{2+}{}_{(aq)} + 2e^-$ *[½ mark]*

$Ag^+{}_{(aq)} + e^- \longrightarrow Ag_{(s)}$ *[½ mark]*

(b)   Overall reaction $Zn_{(s)} + 2Ag^+{}_{(aq)} \longrightarrow Zn^{2+}{}_{(aq)} + 2Ag_{(s)}$

$n(Zn) = \dfrac{m}{M} = \dfrac{32.65}{65.38} = 0.4994 \, mol$ *[1 mark]*

$n(Ag^+) = c \times V = 1.35 \times 0.855 = 1.154 \, mol$ *[1 mark]*

actual ratio: $\dfrac{n(Zn)}{n(Ag^+)} = \dfrac{0.4994}{1.154} = 0.4328$ *[½ mark]*

stoichiometric ratio: $\dfrac{n(Zn)}{n(Ag^+)} = \dfrac{1}{2} = 0.500$ *[½ mark]*

actual ratio < stoichiometric ratio therefore **limiting reagent is Zn**   *[1 mark]*

(c) $Zn_{(s)} \longrightarrow Zn^{2+}{}_{(aq)} + 2e^-$

n(Zn) used up $= 0.4994 \, mol$

$n(e^-) = 2 \times n(Zn) = 2 \times 0.4994 = 0.9988 \, mol$ *[1 mark]*

$n(e^-) = \dfrac{It}{9.649 \times 10^4}$ $\therefore t = \dfrac{n \times 9.649 \times 10^4}{I} = \dfrac{0.9988 \times 9.649 \times 10^4}{0.0718} = 1342259 \, s$ *[1 mark]*

time = 373 hours *or* 15.5 days   *[1 mark]*

(d) $Ag^+_{(aq)} + e^- \longrightarrow Ag_{(s)}$
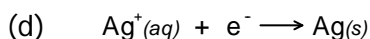
$n(e^-) = 0.9988$ mol

$n(Ag) = 0.9988$ mol   *[1 mark]*

m(Ag) $= n \times M = 0.9988 \times 107.9 = $ **108 g**   *[1 mark]*

(e) $n(Ag^+)$ at start $= 1.154$ mol

$n(Ag^+)$ changed into Ag $= 0.9988$ mol

Therefore, $n(Ag^+)$ left in solution $= 1.154 - 0.9988 = 0.1552$ mol   *[1 mark]*

c(Ag⁺) $= \dfrac{n}{V} = \dfrac{0.1552}{0.855} = $ **0.182 mol L⁻¹**   *[1 mark]*

5.   2.00 tonne of ore contains $\dfrac{1.00 \times 10^{-2}}{100} \times 2.00 \times 10^6 = 200$g Au   *[1 mark]*

Number of troy ounces of Au $= \dfrac{200}{31.3} = 6.390$ troy ounces   *[1 mark]*

Therefore, value of Au mined $= 6.390 \times \$546 = \$3488.94$ *[1 mark]*

<u>Cost of HF</u>:

$4HF_{(aq)} + SiO_{2(s)} \longrightarrow SiF_{4(g)} + 2H_2O_{(l)}$
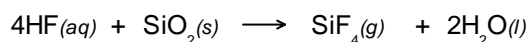
$n(SiO_2) = \dfrac{m}{M} = \dfrac{2.00 \times 10^6}{60.09} = 3.328 \times 10^4$ mol   *[1 mark]*

$n(HF) = 4 \times n(SiO_2) = 4 \times 3.328 \times 10^4 = 1.331 \times 10^5$ mol   *[1 mark]*

$m(100\%$ pure HF$) = n \times M = 1.331 \times 10^5 \times 20.008 = 2.663 \times 10^6$ g   *[1 mark]*

$m(50\%$ commercial HF$) = 2.663 \times 10^6 \times \dfrac{100}{50} = 5.326 \times 10^6$ g   *[1 mark]*

V(commercial HF$) = \dfrac{m}{D} = \dfrac{5.326 \times 10^6}{1.17} = 4.552 \times 10^6$ mL $= 4.552 \times 10^3$ L   *[1 mark]*

Cost of commercial HF $= 4.552 \times 10^3 \times 0.25 = \$1138$ *[1 mark]*

<u>PROFIT</u> from 2.00 tonne quartz $=$ value of Au $-$ cost of HF

$= 3488.94 - 1138 = \$2350.94$

The process is economically feasible (if you only consider the cost of HF) as the profit would be $1175.47 per tonne of ore.   *[1 mark]*

Part 4: Extended Answer Section These type answers are only suggestions so feel free to alter the marks distribution for each section. **[20 marks]**

1.

The table below contains a suggested list of experimental techniques for the task chosen.
[1 mark for each experimental technique that is expressed clearly is a useful and easy way to mark]

% iron in steel wire

Cleaning glassware:
Pipettes and burettes – rinse with detergent solution, then tap water rinses, then distilled water, <u>finally rinse with the solution you are going to put in it</u>. An unbroken film of liquid with no droplets adhering to the glass indicates a clean surface.
Volumetric and conical flasks – rinse with detergent solution, then tap water rinses, <u>finally rinse with distilled water</u>.

[3 marks]

Steps and techniques:
Weigh a mass of steel wire and dissolve it in warm sulfuric acid.
After all the iron has dissolved filter the solution. Rinse the beaker several times with boiled distilled water and pour the washings through the filter paper. Rinse filter paper with some boiled distilled water.

Transfer the filtrate solution containing Fe^{2+} into a clean 250 mL volumetric flask. Rinse the beaker several times with boiled distilled water and transfer the washings to the flask. Bring up to the mark with boiled distilled water using a dropping pipette to get the bottom of the meniscus on the mark when viewed at eye level. Shake the flask to ensure even mixing.

Pipette a 20 mL sample of the Fe^{2+} solution into a clean conical flask making sure that the tip of the pipette is well below the surface, the pipette is held vertically, the bottom of the meniscus is on the mark and the outside of the pipette is wiped clean of any adhering solution. The tip of the pipette should rest on the side of the conical flask and after allowing about 15 seconds to drain, tap the tip once against the side of the flask. There should be some solution still left in the pipette. Do *not* blow this into the conical flask.

Add some $KMnO_4(aq)$ to a burette that has been cleaned and rinsed with a little $KMnO_4(aq)$. Fill to above the zero mark and then let some drain out into a waste beaker in order to fill the burette below the tap and eliminate any air bubbles. It does not matter if the burette reading is below the zero mark.
Add about 10 mL of sulfuric acid to the conical flask containing $Fe^{2+}(aq)$ as the reaction proceeds under acidic conditions.

Run out the permanganate solution from the burette into the flask until a colour change is observed. The end point is reached when the addition of one drop produces a permanent pink colour *(actually a pink colour persists for about 15-20 seconds before disappearing but this is extremely difficult to do for the average student)*. Do not add the permanganate too fast as a brown deposit of MnO_2 could form. Swirl the flask continually and occasionally wash the tip of the burette and sides of the flask with boiled distilled water. This first titration is a rough one and is used as a guide to the amount of permanganate solution you need to run out. Repeat titrations until consistent volumes (within 0.20 mL) are obtained. You will need to read from the top of the meniscus as the purple permanganate solution is too dark to see the bottom of the meniscus.

[14 marks]

Calculation Steps:
Average $n(MnO_4^-)$ delivered from burette
$n(Fe^{2+})$ in conical flask
$n(Fe^{2+})$ in 250 mL volumetric flask
$n(Fe)$ in steel wire
$m(Fe)$ in steel wire
$\%(Fe)$ in steel wire

[3 marks]

Amount of ethanoic acid in vinegar

Cleaning glassware:
Pipettes and burettes – rinse with detergent solution, then tap water rinses, then distilled water, <u>finally rinse with the solution you are going to put in it</u>. An unbroken film of liquid with no droplets adhering to the glass indicates a clean surface.
Volumetric and conical flasks – rinse with detergent solution, then tap water rinses, <u>finally rinse with distilled water</u>.

[3 marks]

Steps and techniques:

Find the density of vinegar by weighing out a known volume then use $D = \dfrac{m}{V}$.

Pipette a 20 mL sample of the vinegar into a clean 250 mL volumetric flask making sure that the tip of the pipette is well below the surface of the vinegar, the pipette is held vertically, the bottom of the meniscus is on the mark and the outside of the pipette is wiped clean of any adhering solution. The tip of the pipette should rest on the side of the volumetric flask and after allowing about 15 seconds to drain, tap the tip once against the side of the flask. There should be some vinegar still left in the pipette. Do *not* blow this into the volumetric flask.

Bring up to the mark with distilled water using a dropping pipette to get the bottom of the meniscus on the mark when viewed at eye level. Shake the volumetric flask to ensure even mixing.

Add some standardized NaOH(aq) to a burette that has been cleaned and rinsed with a little NaOH(aq). Fill to above the zero mark and then let some drain out into a waste beaker in order to fill the burette below the tap and eliminate any air bubbles. It does not matter if the burette reading is below the zero mark.

Pipette 20 mL of the diluted vinegar solution from the volumetric flask into a conical flask and add one to two drops of phenolphthalein indicator, as the equivalence point is slightly basic and this indicator's end point is in the basic range.
Quickly run out the sodium hydroxide solution into the flask until a colour change is observed. The end point is reached when the addition of one drop produces a permanent pink colour. Swirl the flask continually and occasionally wash the tip of the burette and sides of the flask with distilled water from a wash bottle. This first titration is a rough one and is used as a guide to the amount of NaOH solution you need to run out.
Repeat titrations until consistent volumes (within 0.20 mL) are obtained. You will need to read from the bottom of the meniscus and read to two decimal places.

[14 marks]

Calculation Steps:
Average n(NaOH) delivered from burette
n(CH₃COOH) in 20 mL diluted vinegar solution
n(CH₃COOH) in 250 mL diluted vinegar solution
n(CH₃COOH) in 20 mL vinegar sample
m(CH₃COOH) in 20 mL vinegar sample
mass of 20 mL vinegar: = density x volume

% CH₃COOH in vinegar $= \dfrac{m(CH_3COOH)}{m(vinegar)} \times \dfrac{100}{1}$

[3 marks]

2.

Task 1: *In terms of structure and bonding explain the electrical conductivity of metallic, ionic, covalent molecular and covalent network substances. Use examples to assist your explanations.*

   Metals are good electrical conductors because they have mobile, delocalised, valence electrons that can carry the electrical charge. They are able to conduct in the solid and liquid phases. Copper, gold and aluminium are therefore used in electrical and electronic equipment.   *[2 marks]*

   Ionic solids are made up of positive ions and negative ions in fixed lattice positions. They cannot conduct electricity as the ions are not free to move and the electrons are localized to a particular ion and therefore ions and electrons are not available to carry the charge. In the molten form or those that dissolve in water, the ions are dragged away from their fixed lattice positions and are free to move and carry the charge – positive ions (cations) move towards the cathode, and negative ions (anions) move towards the anode. Thus $NaCl(s)$ is a non-conductor of electricity, whereas $NaCl(l)$ and $NaCl(aq)$ do conduct.*[2 marks]*

   Covalent molecular substances are made up of molecules with the valence electrons shared in the covalent bond or localized to a particular atom. There are no mobile electrons or large number of mobile ions to carry the charge in the solid, liquid or gaseous phases, e.g. $CO_2(s)$, $HCl(g)$, $NH_3(g)$, $H_2O(l)$, $C_8H_{18}(l)$. But there are some covalent molecular substances that when dissolved in water form ions which are mobile and can carry the charge as in aqueous ionic solutions, e.g. $HCl(aq)$ ionizes completely in aqueous solution and is a good conductor of electricity; $NH_3(aq)$ ionises to a much lesser extent and therefore is a poor conductor; distilled water is a poor conductor as there are very few mobile $H^+(aq)$ and $OH^-(aq)$
$[10^{-7}$ mol $L^{-1}]$.   *[2 marks]*

   Covalent network substances such as C(diamond); Si; SiO_2, and SiC do not conduct electricity as there are no mobile electrons or ions to carry the charge. An exception to this rule is carbon in the allotropic form of graphite which is a conductor of electricity (not as good as metals though). The structure is a two dimensional layer lattice with every carbon covalently bonded to three other carbon atoms in each layer with weak dispersion forces between the layers. Since all the electrons are not fixed in bonding orbitals, graphite contains mobile electrons and is therefore able to conduct electricity in directions parallel to the layers.
                                                                                               [2 marks]

*[the reason why Si is a semi-conductor and can be doped with boron or phosphorus to form p-type
 semi-conductors or n-type semi-conductors respectively is not required for full marks]*

Task 2: *Isomers and polymers both end in –mers. Explain the difference between them.*

Isomers are compounds with the same molecular formula, but with their atoms in different arrangements *[literally means "equal parts"].* Isomers can be classified into two main types: structural isomers and stereoisomers *[accept geometrical isomers].*
Examples:
  Structural isomers: *[names or diagrams]* butane and 2-methylpropane; 1-butene and 2-butene;
  2-propanone and propanal; ethyl propanoate and propyl ethanoate; 2-methylpentane and
  3-methylpentane.
  Geometric isomers: *[diagram and names essential]* cis-1,2-dichloroethene and
  trans-1,2-dichloroethene.   *[1 mark for definition and 2 marks for diagrams and names = 3 marks]*

Polymers are long chain molecules composed of repeating units of simple molecules called monomers that are linked together. *Poly* means many; *mer* means part or unit. Polymers are commonly called plastics. They are named after the monomer(s) (simple unit(s)) of which they are composed. For example, polyethene (polythene, polyethylene)
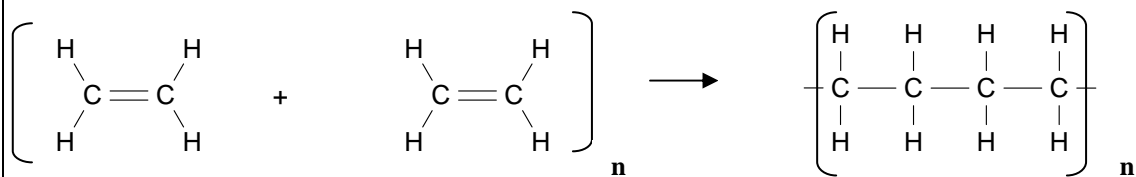
Ethene molecules combine together to give a long chain alkane which is called polyethene, even though it does

not have any C=C double bonds. Polystyrene, poly vinyl acetate and polypropene are names of some common polymers.

They can be classified in various ways.

One such method classifies them into:

    (a) Thermoplastic polymers – those that soften on heating e.g. polythene, PVC

    (b) Thermosetting polymers – those that do not soften on heating but just char, e.g. bakelite

    (c) Elastomers – those that when stretched are able to return easily to their original position, e.g. rubber

They can also be classified by their method of formation.

    (a) Addition polymers – formed from monomers based around a C=C double bond. When added together, by using chemicals known as initiators, the double bond opens and a long chain of C-C single bonds results. e.g. polyvinyl chloride (polychloroethene)

    (b) Condensation polymers – made by combining two different monomers together to form a long chain with water being eliminated.

        (i) polyamides e.g. nylon 6,6 – formed by combining a dicarboxylic acid (hexanedioic acid) and a diamine (1,6-diaminohexane).

        (ii) polyesters e.g. PET (polyethylene terephthalate, polyethene terephthalate) – formed by combining a dicarboxylic acid (terephthalic acid) and a diol (glycol) (1,2-ethenediol).

[1 mark for definition and 3 marks for other facts = 4 marks]

Task 3: *How would you conduct a chemical test to distinguish between ethanol, 2-propanol and 2-methyl-2-propanol?*
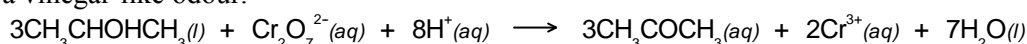
Primary alcohols like ethanol are oxidized by acidified permanganate or acidified dichromate solutions to aldehydes and then to carboxylic acids. In the example below the purple colour of the permanganate ion disappears and the acid product formed would turn blue litmus paper red and give a vinegar-like odour.

$5CH_3CH_2OH_{(l)} + 4MnO_4^-{}_{(aq)} + 12H^+{}_{(aq)} \longrightarrow 5CH_3COOH_{(aq)} + 4Mn^{2+}{}_{(aq)} + 11H_2O_{(l)}$
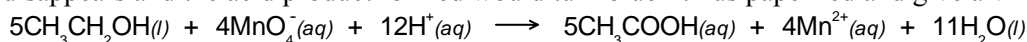
[accept equation for ethanol going to ethanal]

[1 mark for the equation and 1 mark for a relevant observation]

Secondary alcohols like 2-propanol are oxidized by acidified permanganate or acidified dichromate solutions to ketones. In the example below the orange colour of the dichromate ion changes to green when the chromium(III) ion is formed and the product formed *would not* turn blue litmus paper red and *would not give* a vinegar-like odour.

$3CH_3CHOHCH_3{}_{(l)} + Cr_2O_7^{2-}{}_{(aq)} + 8H^+{}_{(aq)} \longrightarrow 3CH_3COCH_3{}_{(aq)} + 2Cr^{3+}{}_{(aq)} + 7H_2O_{(l)}$

*[1 mark for the equation and 1mark for a relevant observation]*

Tertiary alcohols like 2-methyl-2-propanol are not oxidized by acidified permanganate or acidified dichromate solutions and therefore there is no change in colour.   *[1 mark]*

OR

Another test would be the reaction of sodium with the alcohols: The primary alcohol ethanol would react more vigorously than the secondary alcohol 2-propanol, which in turn reacts faster than the tertiary alcohol 2-methyl-2-propanol.   *[3 marks]*
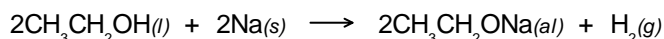
$2CH_3CH_2OH_{(l)} + 2Na_{(s)} \longrightarrow 2CH_3CH_2ONa_{(al)} + H_2{}_{(g)}$ *[2 marks]*

[There are other tests like the Lucas Test where alcohols can be differentiated on the basis of their reaction rates with HCl-ZnCl₂ with primary alcohols having no reaction, secondary alcohols giving a cloudy solution in 5-10 min and tertiary alcohols forming an immediate white solution or separate layer. This is outside the scope of the course but some students could have it as an answer.]