YEAR 12 CHEMISTRY
STAGE 3
2014

MARKING GUIDE

Section One: Multiple-choice **(50 marks)**

1	■ a ☐ b ☐ c ☐ d
2	☐ a ■ b ☐ c ☐ d
3	☐ a ■ b ☐ c ☐ d
4	☐ a ☐ b ☐ c ■ d
5	☐ a ☐ b ■ c ☐ d

6	☐ a ☐ b ☐ c ■ d
7	☐ a ☐ b ☐ c ■ d
8	☐ a ☐ b ☐ c ■ d
9	☐ a ☐ b ■ c ☐ d
10	☐ a ■ b ☐ c ☐ d

11	☐ a ■ b ☐ c ☐ d
12	☐ a ■ b ☐ c ☐ d
13	☐ a ☐ b ■ c ☐ d
14	■ a ☐ b ☐ c ☐ d
15	☐ a ☐ b ☐ c ■ d

16	☐ a ☐ b ☐ c ■ d
17	☐ a ■ b ☐ c ☐ d
18	☐ a ☐ b ☐ c ■ d
19	☐ a ☐ b ■ c ☐ d
20	☐ a ☐ b ■ c ☐ d

21	■ a ☐ b ☐ c ☐ d
22	☐ a ■ b ☐ c ☐ d
23	☐ a ☐ b ☐ c ■ d
24	■ a ☐ b ☐ c ☐ d
25	☐ a ☐ b ■ c ☐ d

(2 marks per question)

Section Two: Short answer (70 marks)

Question 26 (6 marks)

Esters are sweet smelling liquids produced in a reversible process called esterification. The equilibrium constant expression for a particular esterification reaction is shown below.

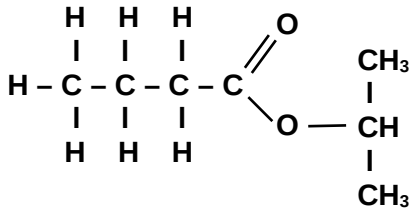
$$K = \frac{[CH_3(CH_2)_2COOCH(CH_3)_2]}{[CH_3(CH_2)_2COOH]\,[CH_3CHOHCH_3]}$$

(a) Write the equation for the esterification reaction taking place. (2 marks)

$$CH_3CH_2CH_2COOH + CH_3CHOHCH_3 \overset{H+}{\rightleftarrows} CH_3CH_2CH_2COOCH(CH_3)_2 + H_2O$$

(1) reactants and products correct
(1) including H_2O and ⇄

(b) Draw the structure of the ester formed in this reaction. (1 mark)



(c) Name the reactants used to produce this ester. (2 marks)

- **butanoic acid**
- **propan-2-ol**

(d) Name the catalyst required for this reaction. (1 mark)

- **sulfuric acid**

Question 27 **(8 marks)**

Potassium (K) is a metallic element and has atomic number 19. It is situated in group 1, period 4 of the periodic table.

(a) Explain why potassium has the largest atomic radius of all the period 4 elements. (2 marks)

- **potassium has smallest core/nuclear charge of all the period 4 elements**
- **valence shell electrons held least strongly, therefore largest a.r.**

(b) Is the first ionisation energy of potassium smaller or larger than sodium? (1 mark)

- **smaller**

The first 5 ionisation energies for potassium are shown in the table below.

	1st	2nd	3rd	4th	5th
Ionisation energy (kJ / mol)	419	3052	4420	5877	7975

(c) Why is the increase between the first and second ionisation energy so large compared with the subsequent increases? (2 marks)

- **potassium has one valence electron therefore relatively easy to remove**
- **subsequent electrons are from an electron shell that is closer to the nucleus and therefore electrons held more tightly and harder to remove**

If potassium metal was placed in a flask of fluorine gas (F_2) an instant, exothermic reaction would take place.

(d) Name the substance that would form. (1 mark)

- **potassium fluoride**

(e) Explain, in terms of ionisation energy and electronegativity, why this reaction between potassium and fluorine occurs. (2 marks)

- **fluorine has very high electronegativity so attracts an electron with great strength**
- **potassium has low ionisation energy so releases its electron relatively easily**

Question 28 **(10 marks)**

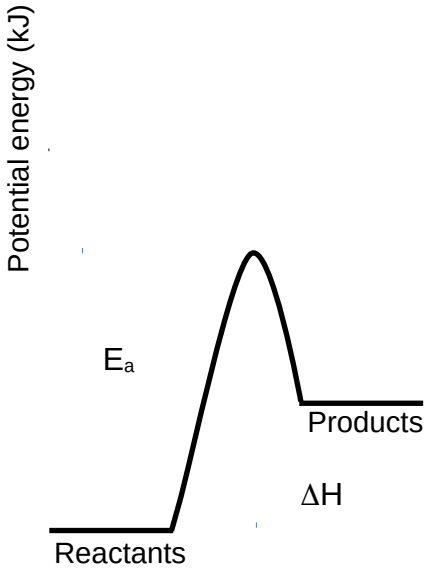
The equilibrium system below forms when concentrated hydrochloric acid is added to a solution containing the blue hexaaquacopper(II) ion. This forms the olive green tetrachlorocuprate(II) ion. When the temperature of this system is increased the solution becomes more green in colour.

$$(Cu(H_2O)_6)^{2+}\ (aq) + 4\ Cl^-\ (aq) \rightleftarrows (CuCl_4)^{2-}\ (aq) + H_2O\ (l)$$
blue *olive green*

(a) Write the equilibrium constant expression for this reaction. (1 mark)

$$K = \frac{[(CuCl_4)^{2-}]}{[(Cu(H_2O)_6)^{2+}]\,[Cl^-]^4}$$

(b) Sketch a potential energy diagram for the above reaction. Label the activation energy and the enthalpy change. (4 marks)



(1) endo shape
(1) ΔH
(1) E_a
(1) reactants/products

(c) If some silver nitrate ($AgNO_3$) solution was added to the equilibrium system above, re-establish equilibrium, what effect would this have on the; (5 marks)

(i) rate of forward reaction **decrease**

(ii) rate of reverse reaction **decrease**

(iii) equilibrium position **shift left / reverse favoured**

(iv) value of K **no change**

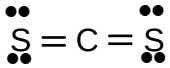
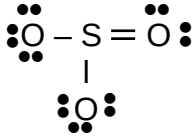
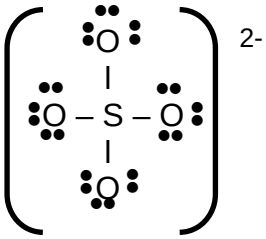
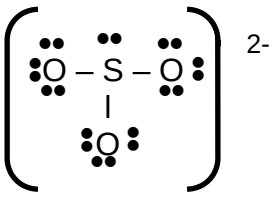
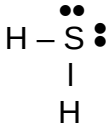
(v) colour of system **more blue (with white ppt forming)**

Question 29 **(9 marks)**

Five sulfur-containing species are listed below. Each of these species has a different shape.

sulfite ion	*hydrogen sulfide*	*carbon disulfide*	*sulfur trioxide*	*sulfate ion*
SO_3^{2-}	H_2S	CS_2	SO_3	SO_4^{2-}

(a) In the table below, draw the structural formula for each species next to its corresponding shape. Represent all valence shell electron pairs either as : or –. (5 marks)

	Structure (showing all valence electrons)
Linear	
Trigonal (triangular) planar	
Tetrahedral	
Pyramidal	
V-shaped / Bent	

(b) Which of the molecules would be regarded as non-polar? (1 mark)

- **CS_2 (and SO_3)**

(c) Which of the molecules contains the most polar intramolecular bonds? (1 mark)

- **H_2S**

(d) When sulfur trioxide is dissolved in water, an acidic solution forms. Use the Bronsted-Lowry theory and chemical equations to show how this occurs. (2 marks)

- **SO_3 dissolves in water to form sulfuric acid; $SO_3 + H_2O \rightarrow H_2SO_4$**
- **Sulfuric acid ionises to produce hydronium ions; $H_2SO_4 + H_2O \rightarrow HSO_4^- + H_3O^+$ (and then $HSO_4^- + H_2O \rightleftarrows SO_4^{2-} + H_3O^+$)**

Question 30 **(8 marks)**

A variety of substances are listed below. Use these substances to answer the following questions. Not all substances must be used, but each substance can only be used **once**.

Na_2CO_3	Na	H_3PO_4	NaCl
Au	H_2SO_4	Na_3PO_4	Cu
$CuCl_2$	Na_2SO_4	Ni	

(a) Which two substances could be mixed together to form a buffer? (1 mark)

- **H_3PO_4 and Na_3PO_4**

(b) Which two substances could be mixed together in water to form a green precipitate? (1 mark)

- **$CuCl_2$ and Na_2CO_3**
  (OR $CuCl_2$ and Na_3PO_4 if answered part a) incorrectly)

(c) Which substance could be classified as a 'basic salt'? Write an hydrolysis equation to support your answer. (2 marks)

- **Na_2SO_4**
- **$SO_4^{2-} + H_2O \rightleftarrows HSO_4^- + OH^-$**
  (OR Na_2CO_3 / Na_3PO_4 if part a) / b) incorrect)

(d) Which substance would react with acid to produce hydrogen gas? (1 mark)

- **Ni**
  (OR Na if part e) incorrect)

(e) Which substance would react with water to produce hydrogen gas? (1 mark)

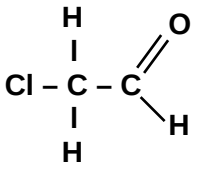
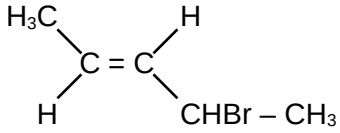
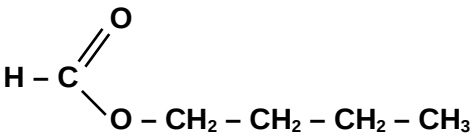
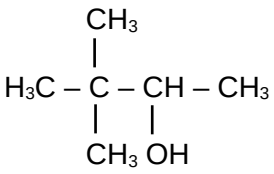
- **Na**

(f) Which metal would displace the silver ions from a solution of silver nitrate? Write the equation for this reaction including only those species that react. (2 marks)

- **Cu**
- **$Cu\ (s) + 2\ Ag^+\ (aq) \rightarrow Cu^{2+}\ (aq) + 2\ Ag\ (s)$**
  (OR Ni / Na if part d) / e) incorrect)

Question 31 **(8 marks)**

(a) Complete the following table by either naming the molecule using the IUPAC system or drawing a structural diagram of the molecule. (4 marks)

	IUPAC Name	Structural Diagram
A	chloroethanal	 
B	**4-bromo-*trans*-pent-2-ene**	
C	butyl methanoate	
D	**3,3-dimethylbutan-2-ol**	

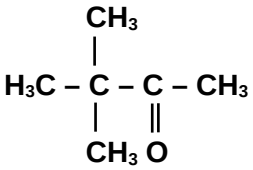
(b) Draw and name the organic product formed when compound B is mixed with iodine water. (2 marks)

Structural Diagram: **$CH_3 - CHI - CHI - CHBr - CH_3$**

IUPAC Name: **4-bromo-2,3-diiodopentane OR 2-bromo-3,4-diiodopentane**

(c) Draw and name the organic product formed when compound D is mixed with acidified potassium permanganate solution. (2 marks)

Structural Diagram:



IUPAC Name: **3,3-dimethylbutanone**

Question 32 **(6 marks)**

For each of the following pairs of molecules;

(i) Circle the one that you would expect to have the highest boiling point, and
(ii) Give a brief explanation for your choice.

(a) ethan-1-amine OR (pentan-1-amine) (2 marks)

- **both are polar molecules with hydrogen bonding and dip-dip forces, but pentanamine has a larger M so therefore stronger dispersion forces**

(b) carbon dioxide OR (sulfur dioxide) (2 marks)

- **sulfur dioxide is polar and has dip-dip forces whereas carbon dioxide is non-polar and only has dispersion forces (sulfur dioxide also has slightly stronger dispersion forces as higher M)**

(c) (methanol) OR methanal (2 marks)

- **both molecules have a similar M (and therefore similar strength dispersion forces), but methanol has hydrogen bonding, whereas methanal has only dipole-dipole forces**

Question 33 **(8 marks)**

The final step in the production of methanol is shown in the equation below.

$$CO\,(g) + 2\,H_2\,(g) \rightleftarrows CH_3OH\,(g) + \text{heat}$$

This reaction is carried out at a high pressure of 50-100 atmospheres, using a $Cu/ZnO/Al_2O_3$ catalyst.

(a) Explain how the use of high pressure will affect the reaction rate. (2 marks)

- **increase reaction rate**
- **high pressure results in a greater number of collisions**

(b) Explain how the use of high pressure will affect the yield of methanol. (3 marks)

- **increase the yield**
- **high pressure will increase the concentration of gas particles**
- **therefore forward reaction will be favoured to decrease the number of gas particles (3 mol → 1 mol)**

(c) What conditions of temperature would increase the yield of methanol? (1 mark)

- **low temp**

(d) State two (2) benefits of using a catalyst in an industrial process. (2 marks)

- **increases reaction rate**
- **saves money (because only small amount needed and can be reused indefinitely)**

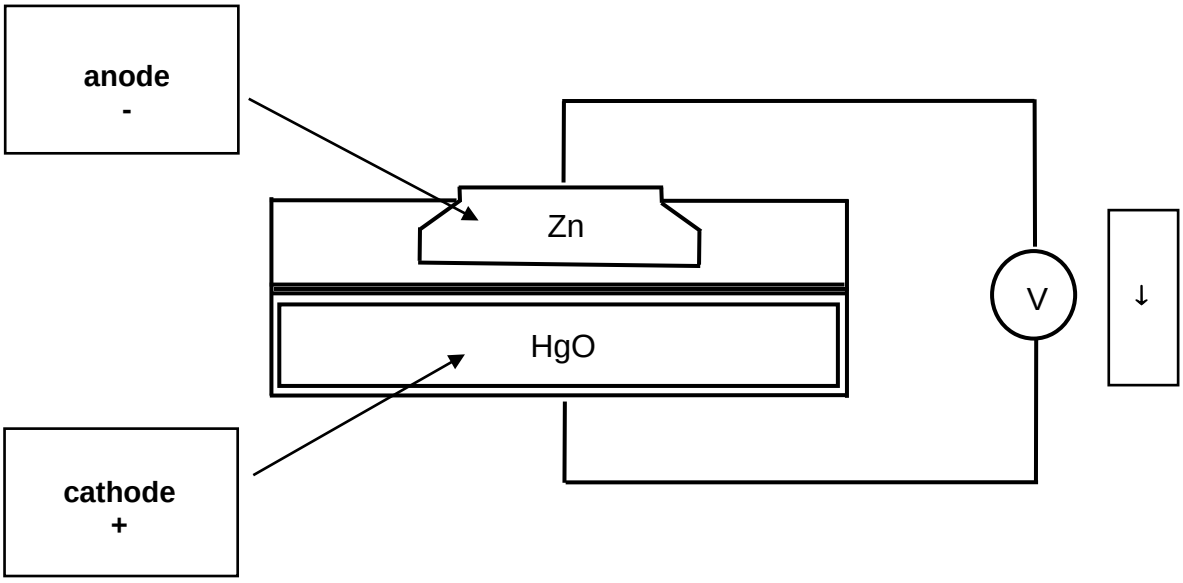
Question 34 **(7 marks)**

The mercury cell is used in watches, calculators and hearing aids due to its small size and long life. It is based on the redox reaction between the mercuric oxide (HgO) and zinc electrodes. As the cell operates, metallic mercury and zinc hydroxide are formed.

(a) Write the oxidation and reduction half equations and the overall redox equation for the mercury cell. (3 marks)

Oxidation half equation	**acidic: $Zn + 2H_2O \rightarrow Zn(OH)_2 + 2H^+ + 2e^-$** **(OR basic: $Zn + 2OH^- \rightarrow Zn(OH)_2 + 2e^-$)**
Reduction half equation	**acidic: $HgO + 2H^+ + 2e^- \rightarrow Hg + H_2O$** **(OR basic: $HgO + H_2O + 2e^- \rightarrow Hg + 2OH^-$)**
Overall redox equation	**$ZnO + HgO + H_2O \rightarrow Zn(OH)_2 + Hg$**

A diagram of the cell is shown below.



(b) In the boxes on the diagram above, label the cathode and anode, the charge of each electrode, and the direction of electron flow. (3 marks)

(c) State an environmental concern associated with this electrochemical cell. (1 mark)

- **Hg is poisonous / toxic**

End of Section Two

Section Three: Extended answer (80 marks)

Question 35 (20 marks)

Soda ash (sodium carbonate, Na_2CO_3) has been used for centuries in the manufacturing of glass, soap, textiles and paper. By the 18th century, production of soda ash had become very expensive so King Louis XVI of France offered a prize to anyone who could devise a method to produce soda ash from sea salt (sodium chloride, NaCl). In 1791 a physician named Nicholas Leblanc developed such a method, known as the Leblanc process.

In the first step, sea salt is mixed with sulfuric acid at a low temperature to produce salt cake (Na_2SO_4).

Step 1: $2\ NaCl\ (s) + H_2SO_4\ (aq) \rightarrow Na_2SO_4\ (s) + 2\ HCl\ (g)$

In the second and third steps, the salt cake is mixed with coal (C) and crushed limestone ($CaCO_3$) and heated at about 1000 ˚C. This converts the salt cake to sodium sulfide. The calcium and sodium then swap ions to produce soda ash and the waste product calcium sulfide.

Step 2: $Na_2SO_4\ (s) + 2\ C\ (s) \rightarrow Na_2S\ (s) + 2\ CO_2\ (g)$

Step 3: $Na_2S\ (s) + CaCO_3\ (s) \rightarrow Na_2CO_3\ (s) + CaS\ (s)$

The final mixture of sodium carbonate and calcium sulfide is called ‘black ash’, due to remaining carbon in the product. The soda ash is separated from the black ash by washing with water. The water is then evaporated to leave solid $Na_2CO_3.10H_2O$. The solid calcium sulfide waste slowly releases hydrogen sulfide (H_2S) gas as it reacts with water and breaks down.

(a) The Leblanc process produces the gases HCl and H_2S as waste products. State a negative environmental consequence associated with each gas. (2 marks)

HCl	**Highly acidic when dissolved in water / Could cause acidification of water and soil / Poisonous gas**
H_2S	**Pungent smell, “rotten egg gas” / Harmful when inhaled / Can also cause acidification of environment**

(b) Step 2 of the Leblanc process is a redox reaction. Identify the substance oxidised and the substance reduced. Use oxidation numbers to support your answer. (4 marks)

- **S in SO_4^{2-} reduced**
- **(+6) to (-2) in S^{2-}**
- **C oxidised**
- **(0) to (+4) in CO_2**

After the final step, the soda ash is separated from the black ash by washing with water.

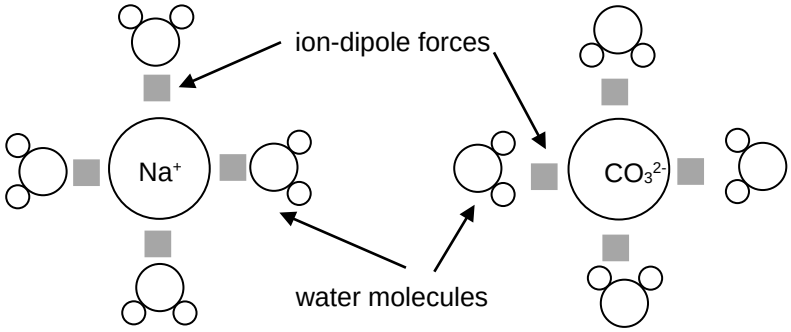
(c) Why is this method able to separate the two components of the black ash? (1 mark)

- **sodium carbonate is soluble in water, calcium sulfide isn't**

(d) In terms of bonding and intermolecular forces, describe what would be happening to the soda ash during this washing process. (2 marks)

- **sodium carbonate would dissociate into Na^+ and CO_3^{2-}**
- **ion-dipole forces would then form between the water and the ions**

(OR may also award marks for correct diagrams)



A factory owner wants to produce 45.0 tonnes of soda ash (Na_2CO_3) using the Leblanc process. He knows that the overall yield of the three-step process is 72.8%.

(e) What mass of sea salt would he need to begin with? (5 marks)

$m(Na_2CO_3)$ = 45 000 000 g

$n(Na_2CO_3)$ = m/M
= 45 000 000 / 105.99
= 424 568.3555 mol

n(NaCl) = $2n(Na_2CO_3)$ x 100/72.8
= 1 166 396.581 mol

m(NaCl) = nM
= 1 166 396.581 x 58.44
= 68 164 216.2 g
= 68.2×10^6 g <u>OR</u> 68.2 t

Many people who lived near the soda ash factories had complained about the ill effects caused by the unrestricted release of hydrogen chloride gas (HCl) into the atmosphere. In 1863, the British parliament passed legislation requiring the factories using the Leblanc process to release no more than 5% of the hydrogen chloride gas into the atmosphere.

By the 1880's a method had been devised to convert the hydrogen chloride gas into chlorine (Cl_2), and then use the chlorine to produce a sodium hypochlorite solution (NaClO).

The two-step reaction process used to recycle the HCl is shown below.

Step 4: $4\ HCl\ (g) + O_2\ (g) \rightarrow 2\ Cl_2\ (g) + 2\ H_2O\ (l)$

Step 5: $Cl_2\ (g) + Na_2CO_3\ (aq) \rightarrow NaClO\ (aq) + CO_2\ (g) + NaCl\ (aq)$

The NaClO solution, commonly known as bleach, was then used as a hospital antiseptic.

If the factory produced 18.0×10^6 L of HCl gas at 142 kPa and 88 ˚C;

(f) What mass of NaClO could theoretically be produced using this two-step recycling process? Assume the maximum allowable HCl emission of 5.00% was released into the atmosphere. (4 marks)

V(HCl recycled) = 0.95 x 18 000 000
= 17 100 000 L

n(HCl recycled) = PV / RT
= (142 x 17 100 000) / (8.314 x 361)
= 809 034.8556 mol

n(NaClO theor.) = n(HCl) / 4 x 2
= 404 517.4278 mol

m(NaClO theor.) = nM
= 404 517.4278 x 74.44
= 30 112 277.3255
= 30.1×10^6 g <u>OR</u> 30.1 t

(g) If 157 kL of 1.94 mol L^{-1} NaClO solution was actually produced, what is the combined yield of the two-step recycling process? (Assume the maximum allowable HCl emission of 5.00% was released into the atmosphere.) (2 marks)

n(NaClO actual) = cV
= 1.94 x 157 000
= 304 580 mol

% yield = n(actual) / n(theor.) x 100
= 304 580 / 404 517.4278 x 100
= 75.2947 %
= 75.3 %

Question 36 **(18 marks)**

Tartaric acid is an antioxidant found in many fruits such as grapes, bananas, plums, cherries and avocados. It can be mixed with baking soda to act as a raising agent in baking and is also one of the main acids present in wine. Tartaric acid contains only the elements carbon, hydrogen and oxygen.

A sample of tartaric acid was isolated and analysed to determine its molecular structure. A 0.273 g sample of tartaric acid was burnt in air to produce 0.320 g of carbon dioxide and 0.0990 g of water.

(a) Determine the empirical formula of tartaric acid. (8 marks)

OR

m(C) = 12.01 / 44.01 x 0.320
= 0.0873256 g

m(H) = (2 x 1.008) / 18.016 x 0.0990
= 0.01107815 g

m(O) = 0.273 - 0.0873256 - 0.01107815
= 0.174596 g

n(C) = 0.0873256 / 12.01
= 0.00727107 mol

n(H) = 0.01107815 / 1.008
= 0.010990228 mol

n(O) = 0.174596 / 16
= 0.010912265 mol

n(C) = n(CO_2)
= m/M
= 0.320 / 44.01
= 0.00727107

m(C) = nM
= 0.00727107 x 12.01
= 0.0873256 g

n(H) = 2 x n(H_2O)
= 2 x (0.0990 / 18.016)
= 0.010990228

m(H) = 0.010990228 x 1.008
= 0.01107815 g

m(O) = 0.273 - 0.0873256 - 0.01107815
= 0.174596 g

n(O) = 0.174596 / 16
= 0.010912265 mol

	C	H	O
ratio	1	1.5	1.5
X2	2	3	3

Therefore EF is $C_2H_3O_3$

When a sample of tartaric acid was vaporised at 142 kPa and 355 ˚C, it was found to have a density of 4.08 g L^{-1}.

(b) Determine the molecular formula of tartaric acid. (4 marks)

Density gives a mass of 4.08 g for every 1 L, therefore n in 1 L;

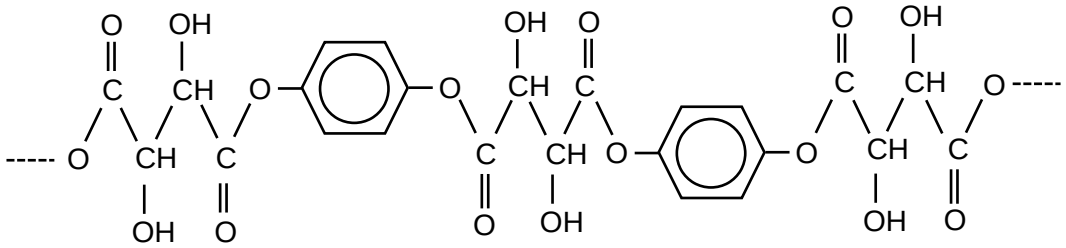
$n(C_xH_yO_z)$ = PV / RT
= 142 x 1 / (8.314 x 628)
= 0.027196854 mol

$M(C_xH_yO_z)$ = m/n
= 4.08 / 0.027196854
= 150.0173476 g mol^{-1}

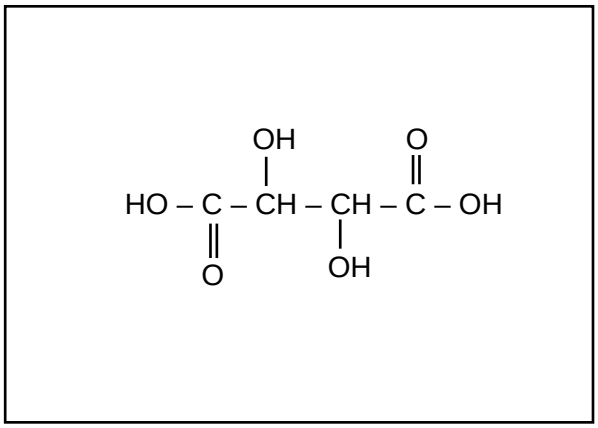
$M(C_xH_yO_z)$ / M(EF) = 150.0173476 / 75.044
= 1.999

Therefore MF is $C_4H_6O_6$

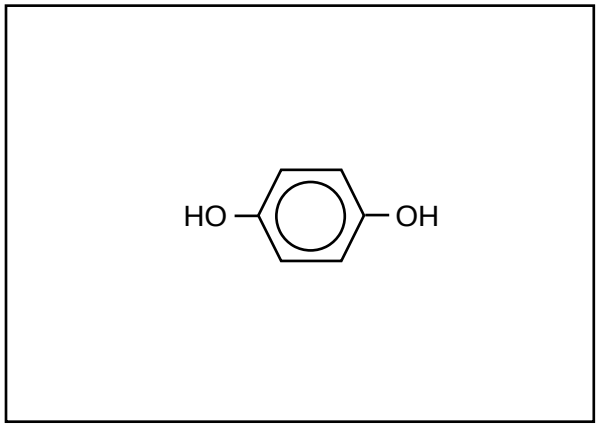
The section of polymer shown below has been formed from tartaric acid and a second molecule called hydroquinone.



(c) Draw the structure of the two monomers used to create this polymer. (3 marks)



tartaric acid



hydroquinone

(2) marks for correct diagrams, (1) mark for having them in correct boxes

(d) Is this an example of addition or condensation polymerisation? (1 mark)

- **condensation**

(e) Briefly explain the difference between addition and condensation polymerisation. (2 marks)

- **addition polymerisation requires the presence of a C=C double bond, the double bond breaks and monomers link together**
- **condensation polymerisation requires 2 functional groups to join together, in the process eliminating a molecule of (usually) water**

Question 37 **(13 marks)**

It was the night of the Year 12 Ball and everything had been going well until Mr Crucible, the chemistry teacher, saw some students acting suspiciously near the punch bowl. Suspecting that the punch had been spiked, he quickly confiscated the whole bowl and took a sample back to the lab so he could perform a titration to determine the alcohol concentration (if indeed there was any).

The bowl had contained 12.0 L of punch in total. Mr Crucible took a 50.0 mL sample of the punch and diluted it to 250 mL in a volumetric flask. He then took 20.0 mL aliquots of the dilute solution and titrated them against a standard solution of 0.0200 mol L^{-1} sodium dichromate.

The relevant half equations for the titration are shown below;

ox: $CH_3CH_2OH\ (aq) + H_2O\ (l) \rightarrow CH_3COOH\ (aq) + 4\ H^+\ (aq) + 4\ e^-$

red: $Cr_2O_7^{2-}\ (aq) + 14\ H^+\ (aq) + 6e^- \rightarrow 2\ Cr^{3+}\ (aq) + 7\ H_2O\ (l)$

(a) Write the overall equation for the titration reaction. (1 mark)

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

(b) What observations would you expect to see as this reaction took place? (1 mark)

- **orange to green**

The results of Mr Crucible's titration are shown in the table below.

	1	2	3	4	5
Final (mL)	24.15	45.45	22.20	43.90	47.90
Initial (mL)	1.70	24.15	0.85	22.20	26.60
Titre (mL)	**22.45**	**21.3**	**21.35**	**21.7**	**21.3**

(c) Calculate the average titre of sodium dichromate used. (1 mark)

(21.3 + 21.35 + 21.3) / 3 = 21.317 mL

(d) Calculate the concentration (in mol L^{-1}) of alcohol in the punch. (5 marks)

$n(Cr_2O_7^{2-})$ = cV
= 0.02 x 0.021317
= 0.00042634 mol

$n(CH_3CH_2OH$ in 20 mL aliquot) = 0.00042634 / 2 x 3
= 0.00063951 mol

$n(CH_3CH_2OH$ in 250 mL flask) = 0.00063951 / 20 x 250
= 0.0079939 mol
= $n(CH_3CH_2OH$ in 50 mL of punch)

$C(CH_3CH_2OH$ in punch) = n/V
= 0.0079939 / 0.050
= 0.1598775 mol L^{-1}
= 0.160 mol L^{-1}

Mr Crucible weighed a sample of the punch and found the density to be 1.03 g mL^{-1}.

(e) Calculate the concentration of alcohol in the punch in parts per million. (5 marks)

in a 50 mL sample;

$m(CH_3CH_2OH)$ = nM
= 0.0079939 x 46.068
= 0.368263 g

= 368.263 mg

m(punch) = ρ x V
= 1.03 x 50
= 51.5 g

= 0.0515 kg

ppm = mg alcohol / kg punch
= 368.263 / 0.0515
= 7150.7376 ppm
= 7.15 x 10^3 ppm

Question 38 **(17 marks)**

A mechanic was working on an engine when he knocked over an old car battery and sulfuric acid started to leak out onto the floor. He knew that sulfuric acid was quite corrosive and dangerous so he looked around for something to clean up the mess. He saw some 'Drano' (drain cleaner) in the kitchen cupboard, which the label said contained 350 g L^{-1} sodium hydroxide. He took the bottle and poured some on the acid spill to try and neutralise it.

(a) A car battery is an example of a secondary cell. What does this mean? (1 mark)

- **cell is rechargeable**

(b) What is the function of the sulfuric acid in a car battery? (1 mark)

- **electrolyte**

The equation for the neutralisation reaction that took place is shown below.

$$H_2SO_4\ (aq) + 2\ NaOH\ (aq) \rightarrow Na_2SO_4\ (aq) + 2\ H_2O\ (l)$$

The mechanic had spilled 217 mL of sulfuric acid with a concentration of 4.60 mol L^{-1}. If he poured 234 mL of 'Drano' over the spill;

(c) Calculate the limiting reagent. (6 marks)

m(NaOH) = cV
= 350 x 0.234
= 81.9 g

	H_2SO_4	**NaOH**
n(present)	**n = cV** **= 4.6 x 0.217** **= 0.9982 mol**	**n = m/M** **= 81.9 / 39.998** **= 2.0476 mol**
n(required)	**n = 2.0476 / 2** **= 1.0238 mol**	**n = 0.9982 x 2** **= 1.9964 mol**

Therefore H_2SO_4 is LR

<u>OR</u>

Stoichiometric ratio NaOH / H_2SO_4 = 2 / 1 = 2
Actual ratio NaOH / H_2SO_4 = 2.0476 / 0.9982 = 2.0513

Therefore H_2SO_4 is LR

(d) Calculate the mass of excess reagent. (3 marks)

n(xs NaOH) = 2.0476 – 1.9964
= 0.05120238 mol

m(xs NaOH) = nM
= 0.05120238 x 39.998
= 2.04799 g
= 2.05 g

(e) Calculate the final pH of the spilled mixture. (4 marks)

n(xs OH^-) = 0.05120238 mol

c(xs OH^-) = n/V_{total}
= 0.05120238 / 0.451
= 0.11353 mol L^{-1}

[H_3O^+] = (1.0×10^{-14}) / 0.11353
= 8.808184×10^{-14} mol L^{-1}

pH = -log (8.808184×10^{-14})
= 13.055
= 13.1

(f) Give a brief description of how an electrochemical cell produces electricity. (2 marks)

- **oxidation and reduction half reactions are physically separated, so for the redox reaction to occur the electrons divert through an external pathway, thereby creating an electric current**

Question 39 **(12 marks)**

Two high school chemistry students were carrying out a titration to determine the concentration of acetic (ethanoic) acid in a sample of white vinegar.

Firstly they measured exactly 25.0 mL of the vinegar into a clean, dry 250 mL volumetric flask. They added distilled water to the flask until the bottom of the meniscus of the water was exactly on the 250 mL line. They inverted the flask to mix the solution thoroughly.

The students then took a clean 20.0 mL pipette, rinsed it with some distilled water, and placed an aliquot of the diluted vinegar into a clean, dry conical flask. They added 3 drops of methyl orange to the flask and set it aside while they prepared the primary standard.

They decided to use sodium hydroxide as a primary standard, so they carefully weighed out and recorded the mass of sodium hydroxide to three decimal places. They dissolved the sodium hydroxide in some distilled water, transferred all the solution to a clean, dry 500 mL volumetric flask and then added more distilled water until the bottom of the meniscus of the water was exactly on the 500 mL line.

The students used some of the sodium hydroxide solution to rinse the burette and then filled the burette with the solution, ensuring they didn't go over the maximum 50.0 mL level.

They then performed and repeated the titration until they obtained 3 consistent results from which to calculate the average titre.

(a) State three (3) things the students did **correctly**. (3 marks)

- **used clean volumetric flasks**
- **ensured bottom of meniscus was on the fill line**
- **inverted volumetric flask to mix thoroughly**
- **rinsed burette with NaOH**
- **repeated titration to achieve 3 consistent results** **(any 3)**

(b) Find three (3) things that the students did **incorrectly** and;

(i) State the error they made
(ii) State and explain what they should have done.

(9 marks)

1. (i) **rinsed pipette with distilled water (1)**
   (ii) **should have rinsed with diluted vinegar solution, water drops will dilute pipette solution (2)**

2. (i) **used methyl orange (1)**
   (ii) **should have used phenolphthalein, methyl orange end point will occur too early and result in smaller volume of NaOH being added (2)**

3. (i) **used NaOH as primary standard (1)**
   (ii) **need to choose a more appropriate primary standard, NaOH is deliquescent and M is too low (2)**

End of questions