

MARK SCHEME

EDWEST CHEMISTRY STAGE 3 PAPER 2011

Section One

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

Section Two

26. (a) (3)

Change	Effect
Adding dilute nitric acid	DECREASE
Adding sodium hydroxide solution	INCREASE
Adding silver nitrate solution	INCREASE

- (b) (1)

Equilibrium constant expression	$\frac{[\text{H}_3\text{AsO}_4][\text{H}^+][\text{I}^-]^2}{[\text{H}_3\text{AsO}_3][\text{I}_2]}$
---------------------------------	---

27 (a) Endothermic (1)

(b) (3)

Change	Effect
Increasing the temperature	INCREASE
Increasing the volume of the system	DECREASE
Adding a catalyst	INCREASE

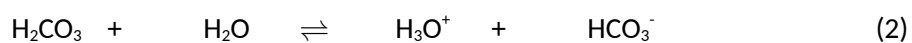
28. (a) Basic (1)

(b) Phosphate ions hydrolyse in water (1)

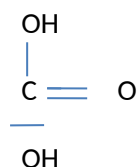


OH⁻ ions produced hence basic (1)

29. (a)



(b) (1)



(c) As [H⁺] increases reverse reaction is favoured (1) which would decrease concentration of H₃O⁺ (1)

(d) 3.98 x 10⁻⁸ mol L⁻¹ (1)

30. Ethanol and water have H-bonding between molecules (1) and so can disrupt the inter molecular bonds (1). Paraffin has only dispersion forces between molecules (1). Therefore ethanol cannot disrupt bonding and form bonds itself with the paraffin. (1)

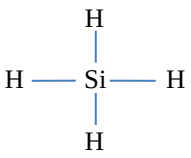
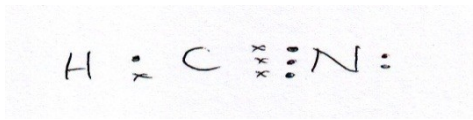
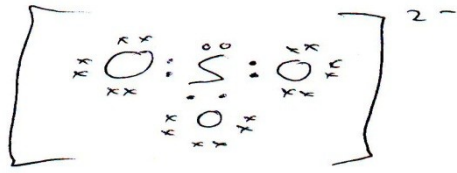
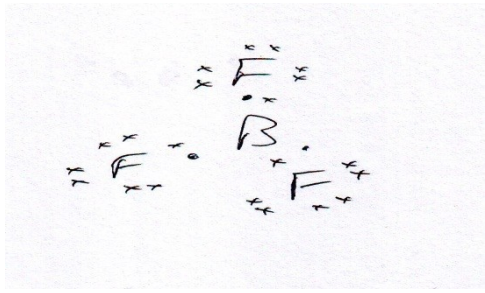
31. (a) An excess of 2-propanol is oxidised by acidified KMnO_4 (3 marks)

Observations	Colour change from purple to colourless (or pale pink)
Structural formula of organic product Show all atoms	CH_3COCH_3
Name of organic product	propanone

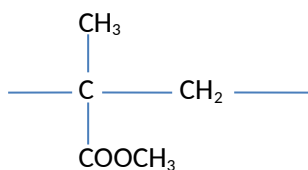
(b) Methanoic acid reacts with 1-butanol in the presence of H_2SO_4 (3 marks)

Observations	Fruity smell produced (accept no visible reaction)
Structural formula of organic product Show all atoms	$\text{C}_4\text{H}_9\text{OOCH}$
Name of organic product	Butyl methanoate

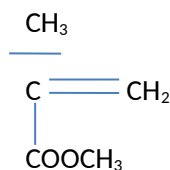
32.

Species	Structure (showing all valence shell electrons)	Shape (sketch or name)	Polarity of molecule (polar or non-polar)
Silicon hydride SiH_4		Tetrahedral	Non-polar
Hydrogen cyanide HCN		Linear	Non-polar
Sulfite ion SO_3^{2-}	 <p>No brackets or charge no mark</p>	Pyramidal	Polar
Boron trifluoride BF_3		Trigonal Planar	Non-polar

33. (a) Repeating unit is (1)



(b) (1)

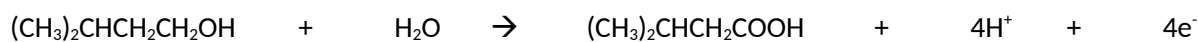


(c) Addition (1)

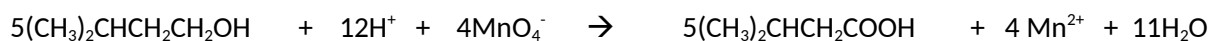
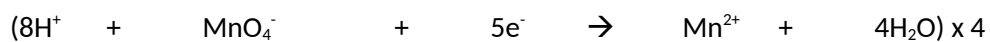
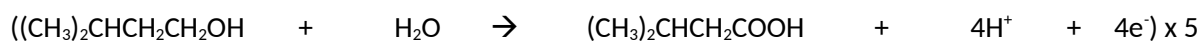
(d) Ester (1)

34. (a) 3-methylbutanoic acid (1)

(b) (2)



(c) (3)



1 mark for each equation (pay follow through for 3rd equation)

35. (a)

(i) Salt bridge drawn and labelled with suitable salt (1)

(ii) Cathode labelled – Ag/Ag⁺ (1)

(iii) Direction of electron flow labelled – from Ag to Cu (1)

(iv) Anode labelled – Cu/Cu²⁺ (1)

(b)

(i) Anode Cu → Cu²⁺ + 2e⁻ (1)

(ii) Cathode Ag⁺ + e⁻ → Ag (1)

(c) 0.46 V (1)

36. (a) Excludes water and oxygen from the surface of the iron (2) which are two of the reactants needed for rust to form (1)

(b) Fe → Fe²⁺ + 2e⁻ -0.44 V

Sn → Sn²⁺ + 2e⁻ -0.14V (1)

Fe stronger reductant than Sn (1)

Therefore Fe corrodes as electrochemical cell is formed (1)

(c) Zn → Zn²⁺ + 2e⁻ -0.76 V

Fe → Fe²⁺ + 2e⁻ -0.44 V (1)

Zn stronger reductant than Fe (1)

Therefore Zn corrodes as electrochemical cell is formed (1)

(d) Electrochemical cell formed (1) where Al and Fe are joined (1)

Al stronger reductant than Fe (1)

Therefore Al corrodes (1)

Section Three

37. (a)

$$\begin{aligned} n(\text{KHC}_4\text{H}_4\text{O}_6) &= 350 / (39.1 + 1.008 + 4 \times 12.01 + 1.008 \times 4 + 16 \times 6) \\ &= 350 / 188.18 \\ &= 1.8599 \text{ mol} \end{aligned} \quad (1)$$

$$\begin{aligned} n(\text{NaHCO}_3) &= 150 / (22.99 + 1.008 + 12.01 + 3 \times 16) \\ &= 150 / 84.008 \\ &= 1.7855 \text{ mol} \end{aligned} \quad (1)$$



$$1.8599 > 1.7855$$

Therefore NaHCO_3 is limiting reagent (2)

If students have correct answer but no working – no marks

$$\begin{aligned} (b) \quad n(\text{KHC}_4\text{H}_4\text{O}_6)_{\text{excess}} &= 1.8599 - 1.7855 \\ &= 0.0744 \end{aligned} \quad (2)$$

$$\begin{aligned} m(\text{KHC}_4\text{H}_4\text{O}_6) &= 0.0744 \times 188.18 \\ &= 14.0 \text{ g} \end{aligned} \quad (1)$$

$$(c) \quad 1.7855 \text{ mol NaHCO}_3 \rightarrow 1.7855 \text{ mol CO}_2 \quad (1)$$

$$\begin{aligned} V(\text{CO}_2) &= (1.7855 \times 8.315 \times 453) / 105 \\ &= 64.1 \text{ L} \end{aligned} \quad (2)$$

$$\begin{aligned} (d) \quad \text{Let amount of NaHCO}_3 &= x \text{ g} \\ \text{Amount of (KHC}_4\text{H}_4\text{O}_6) &= (500-x) \text{ g} \end{aligned} \quad (1)$$

$$n(\text{KHC}_4\text{H}_4\text{O}_6) = n(\text{NaHCO}_3)$$

$$(500-x) / 188.18 = x / 84.008$$

$$(500-x) 84.008 = 188.18x$$

$$42004 - 84.008x = 188.18x$$

$$42004 = 188.18x + 84.008x$$

$$272.19x = 42004$$

$$x = 42004/272.19$$

$$= 154 \text{ g} \quad (2)$$

$$m(\text{KHC}_4\text{H}_4\text{O}_6) = 500 - 154$$

$$= 346 \text{ g} \quad (1)$$

Both answers quoted to 3 significant figures (1)

38.

Final reading (mL)	20.60	19.65	20.75	20.80	19.05
Initial reading (mL)	4.50	3.80	5.25	5.00	3.20
Titration volume (mL)	16.10	15.85	15.50	15.80	15.85

$$(a) (15.85 + 15.85 + 15.80)/3 = 15.83 \text{ mL} \quad (1)$$



(c) Suitable indicator named (almost any would do) (1)

Titration of strong acid with strong base (1)

Equivalence point around pH 7 (1)

End point of indicator somewhere between pH 3-10 due to titration curve (1)

$$(d) [\text{OH}^-] = [\text{NaOH}] = 10^{-14}/5.0119 \times 10^{-14} \\ = 0.19953 \text{ mol L}^{-1} \quad (1)$$

$$n(\text{NaOH}) = 0.02 \times 0.19953 \\ = 3.9906 \times 10^{-3} \text{ mol} \quad (1)$$

$$n(\text{H}_2\text{SO}_4) = 3.9906 \times 10^{-3}/2 \\ = 1.9953 \times 10^{-3} \text{ mol} \quad (1)$$

$$\begin{aligned}
 n(\text{H}_2\text{SO}_4) &= (1.9953 \times 10^{-3} \times 500)/15.83 \\
 &= 0.063023 \text{ mol} & (1) \\
 &= n(\text{H}_2\text{SO}_4) \text{ in } 10 \text{ mL} & (1) \\
 \text{C}(\text{H}_2\text{SO}_4) \text{ in battery} &= 0.063023/0.01 \\
 &= 6.30 \text{ molL}^{-1} & (1)
 \end{aligned}$$

39. (a)

$$\begin{aligned}
 m(\text{C}) &= (5.51 \times 12.01)/44.01 = 1.5036 \text{ g} \\
 \% \text{C} &= (1.5036 \times 100)/2.31 = 65.1\% & (1) \\
 m(\text{H}) &= (2.81 \times 1.008 \times 2)/18.016 = 0.31444 \text{ g} \\
 \% \text{H} &= (0.31444 \times 100)/2.31 = 13.6\% & (1) \\
 \% \text{O} &= 100 - 65.1 - 13.6 = 21.3\% & (1)
 \end{aligned}$$

	C	H	O
Ratio by mass	65.1	13.6	21.3
Ratio by mol	65.1/12.01	13.6/1.008	21.3/16
	5.42	13.49	1.33
Divide by smallest	5.42/1.33	13.49/1.33	1.33/1.33
	4.075	10.143	1
	4	10	1
Empirical formula	$\text{C}_4\text{H}_{10}\text{O}$		

(4)

$$(b) \quad 4 \times 12.01 + 1.008 \times 10 + 16 = 74.12 \quad (1)$$

Therefore molecular formula = empirical formula

$$\text{Molecular formula} = \text{C}_4\text{H}_{10}\text{O} \quad (1)$$

(c)

Draw and name two possible structures of compound X

(4 marks)

Structure	Structure
$\text{CH}_3\text{CH}_2\text{CH}_2\text{CHO}$	$\text{CH}_3\text{CHCH}_3\text{CHO}$
Name	Name
Butanal	methylpropanal

Draw and name two possible structures of compound Y.

(4 marks)

Structure	Structure
$\text{CH}_3\text{CH}_2\text{CH}_2\text{COOH}$	$\text{CH}_3\text{CHCH}_3\text{COOH}$
Name	Name
Butanoic acid	Methylpropanoic acid

40. (a)

$$\begin{aligned}n(\text{Mg}_2\text{P}_2\text{O}_7) &= 0.0364 / (24.31 \times 2 + 2 \times 30.97 + 16 \times 7) \\&= 0.0364 / 222.56 \\&= 1.63551 \times 10^{-4} \text{ mol} & (1) \\2 \text{ mol MgNH}_4\text{PO}_4 &\rightarrow 1 \text{ mol Mg}_2\text{P}_2\text{O}_7 & (1) \\n(\text{MgNH}_4\text{PO}_4) &= 2 \times 1.63551 \times 10^{-4} \text{ mol} \\&= 3.27102 \times 10^{-4} \text{ mol} & (1)\end{aligned}$$

$$n(\text{MgNH}_4\text{PO}_4) = n(\text{PO}_4^{3-}) \text{ in 20 mL} = 3.27102 \times 10^{-4} \text{ mol} \quad (1)$$

$$\begin{aligned} n(\text{PO}_4^{3-}) \text{ in 250 mL} &= (3.27102 \times 10^{-4} \times 250)/20 \\ &= 4.0888 \times 10^{-3} \text{ mol} \end{aligned} \quad (1)$$

$$\begin{aligned} m(\text{PO}_4^{3-}) &= 4.0888 \times 10^{-3} \times (30.97 + 16 \times 4) \\ &= 0.38831 \text{ g} \end{aligned}$$

$$\begin{aligned} \% &= (0.38831 \times 100)/6.15 \\ &= 6.31\% \end{aligned} \quad (1)$$

(b) (4)

Action	Calculated result would be too low	No effect on calculated result	Calculated result would be too high
A. All of the MgNH_4PO_4 was not precipitated.	√		
B. All of the fertiliser did not dissolve.	√		
C. The conical flask had been previously washed with water but not dried.		√	
D. The MgNH_4PO_4 precipitate was not washed with water.			√

Makes no difference to the number of mol of phosphate ions transferred to the conical flask. (1)

(c) 50.0 kg of fertiliser contains 5.00 kg of K (1)

$$n(\text{K}) = 5000/39.1 = 127.88 \text{ mol}$$

$$n(\text{K}) = n(\text{KNO}_3) = 127.88 \text{ mol} \quad (1)$$

$$\begin{aligned} m(\text{KNO}_3) &= 127.88(39.1 + 14.01 + 16 \times 3) \\ &= 12930 \text{ g} \\ &= 12.9 \text{ kg} \end{aligned} \quad (1)$$

(d) Soluble (1) and also contains N which is a nutrient. (1)

41.

(a) $m(\text{Cu}) = 98\% \times 10^6 \text{ g}$
 $= 980\,000 \text{ g} \quad (1)$
 $n(\text{Cu}) = 980\,000/63.55$
 $= 15421 \text{ mol} \quad (1)$
 $1 \text{ mol Cu} \rightarrow 1 \text{ mol CuFeS}_2 \quad (1)$
 $15421 \text{ mol Cu} \rightarrow 15421 \text{ mol CuFeS}_2 \quad (1)$
 $m(\text{CuFeS}_2) = 15421 \times (63.55 + 55.85 + 32.06 \times 2)$
 $= 15421 \times 183.52$
 $= 2.83 \text{ tonnes} \quad (1)$

(b) $n(\text{Cu}) = 15421 \text{ mol}$
 $1 \text{ mol Cu} = 3 \text{ mol SO}_2 \quad (1)$
 $15421 \text{ mol Cu} = 3 \times 15421 \text{ mol SO}_2$
 $= 46263 \text{ mol SO}_2 \quad (1)$
 $150 \times V(\text{SO}_2) = 46263 \times 8.315 \times 1773$
 $V(\text{SO}_2) = (46263 \times 8.315 \times 1773)/150$
 $= 4.55 \times 10^6 \text{ L} \quad (2)$

(c) Acid rain (1)

42.

Some points to consider

- Solubility and boiling points will depend upon extent of H-bonding
- All are alcohols so have -OH group and will H-bond
- Strength of H-bond will depend on the extent to which the -OH group is exposed and available for bonding
- Compounds differ as they are all isomers of C_4H_9OH
- 1-butanol and 2-methyl-1-propanol are primary alcohols
- 2-butanol is a secondary alcohol
- 2-methyl-2-propanol is a tertiary alcohol
- Structural formulas would be good if drawn
- Expect primary alcohols to be more soluble and have a highest BPs as -OH is more exposed and available for H-bonding
- Tertiary alcohol will be least soluble and lowest Bpt as H-bonding is weakest of the compounds as -OH group is least exposed
- Need to discuss solubility as between molecules that can form intermolecular bonds with each other
- All exhibit dispersion forces