MARK SCHEME

EDWEST CHEMISTRY STAGE 3 PAPER 2011

Section One

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

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	$\dfrac{[H_3AsO_4][H^+][I^-]^2}{[H_3AsO_3][I_2]}$

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)

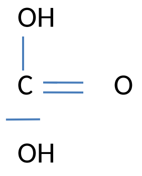
PO_4^{3-} + H_2O $\rightleftharpoons$ HPO_4^{2-} + OH^- (1)

OH^- ions produced hence basic (1)

29. (a)

H_2CO_3 + H_2O $\rightleftharpoons$ H_3O^+ + HCO_3^- (2)

(b) (1)



(c) As $[H^+]$ increases reverse reaction is favoured (1) which would decrease concentration of H_3O^+(1)

(d) 3.98×10^{-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)

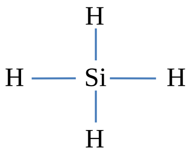
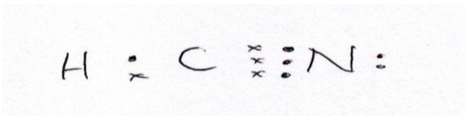
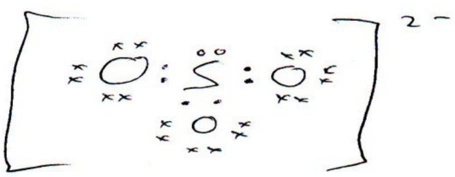
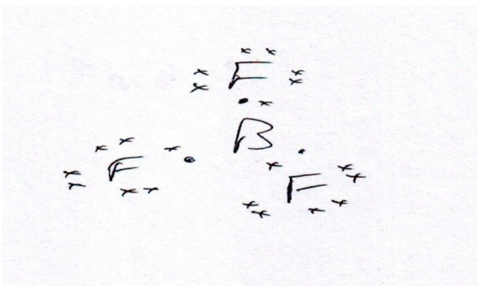
31. (a) An excess of 2-propanol is oxidised by acidified $KMnO_4$ (3 marks)

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

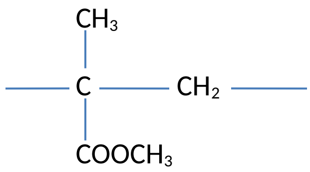
(b) Methanoic acid reacts with 1-butanol in the presence of H_2SO_4 (3 marks)

Observations	Fruity smell produced (accept no visible reaction)
Structural formula of organic product Show all atoms	C_4H_9OOCH
Name of organic product	Butyl methanoate

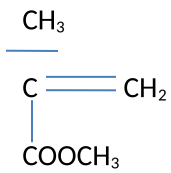
32.

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-}	 No brackets or charge no mark	Pyramidal	Polar
Boron trifuoride 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)

$(CH_3)_2CHCH_2CH_2OH + H_2O \rightarrow (CH_3)_2CHCH_2COOH + 4H^+ + 4e^-$

(c) (3)

$((CH_3)_2CHCH_2CH_2OH + H_2O \rightarrow (CH_3)_2CHCH_2COOH + 4H^+ + 4e^-) \times 5$

$(8H^+ + MnO_4^- + 5e^- \rightarrow Mn^{2+} + 4H_2O) \times 4$

$5(CH_3)_2CHCH_2CH_2OH + 12H^+ + 4MnO_4^- \rightarrow 5(CH_3)_2CHCH_2COOH + 4\,Mn^{2+} + 11H_2O$

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/Cu^{2+} (1)

(b)

(i) Anode $Cu \rightarrow Cu^{2+} + 2e^-$ (1)

(ii) Cathode $Ag^+ + e^- \rightarrow Ag$ (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) $Fe \rightarrow Fe^{2+} + 2e^-$ -0.44 V

$Sn \rightarrow Sn^{2+} + 2e^-$ -0.14V (1)

Fe stronger reductant than Sn (1)

Therefore Fe corrodes as electrochemical cell is formed (1)

(c) $Zn \rightarrow Zn^{2+} + 2e^-$ -0.76 V

$Fe \rightarrow Fe^{2+} + 2e^-$ -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)

$n(KHC_4H_4O_6)$ = 350/(39.1+1.008+4x12.01+1.008x4+16x6)

= 350/188.18

= 1.8599 mol (1)

$n(NaHCO_3)$ = 150/(22.99+1.008+12.01+3x16)

= 150/84.008

= 1.7855 mol (1)

1 mol $KHC_4H_4O_6$ $\rightarrow$ 1 mol $NaHCO_3$

1.8599 > 1.7855

Therefore $NaHCO_3$ is limiting reagent (2)

If students have correct answer but no working – no marks

(b) $n(KHC_4H_4O_6)$excess = 1.8599 – 1.7855

= 0.0744 (2)

$m(KHC_4H_4O_6)$ = 0.0744 x 188.18

= 14.0 g (1)

(c) 1.7855 mol $NaHCO_3$ $\rightarrow$ 1.7855 mol CO_2 (1)

$V(CO_2)$ = (1.7855 x 8.315 x 453)/105

= 64.1 L (2)

(d) Let amount of $NaHCO_3$ = x g

Amount of $(KHC_4H_4O_6)$ = (500-x)g (1)

$n(KHC_4H_4O_6)$ = $n(NaHCO_3)$

(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 g (2)

m ($KHC_4H_4O_6$) = 500 – 154

= 346 g (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 mL (1)

(b) $2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$ (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) $[OH^-]$ = [NaOH] = $10^{-14}/5.0119 \times 10^{-14}$

= $0.19953\ molL^{-1}$ (1)

n(NaOH) = 0.02×0.19953

= 3.9906×10^{-3} mol (1)

n(H_2SO_4) = $3.9906 \times 10^{-3}/2$

= 1.9953×10^{-3} mol (1)

$n(H_2SO_4)$ = $(1.9953 \times 10^{-3} \times 500)/15.83$

= 0.063023 mol (1)

= $n(H_2SO_4)$ in 10 mL (1)

C (H_2SO_4) in battery = 0.063023/0.01

= 6.30 $molL^{-1}$ (1)

39. (a)

m(C) = (5.51 x 12.01)/44.01 = 1.5036 g

%C = (1.5036 x 100)/2.31 = 65.1% (1)

m(H) = (2.81 x 1.008 x 2)/18.016 = 0.31444 g

%H = (0.31444 x 100)/2.31 = 13.6% (1)

%O = 100 – 65.1 – 13.6 = 21.3% (1)

	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 $C_4H_{10}O$ (4)

(b) 4 x 12.01 + 1.008 x 10 + 16 = 74.12 (1)

Therefore molecular formula = empirical formula

Molecular formula = $C_4H_{10}O$ (1)

(c)

Draw and name two possible structures of compound X (4 marks)

Structure	Structure
$CH_3CH_2CH_2CHO$	CH_3CHCH_3CHO
Name Butanal	Name methylpropanal

Draw and name two possible structures of compound Y. (4 marks)

Structure	Structure
$CH_3CH_2CH_2COOH$	CH_3CHCH_3COOH
Name Butanoic acid	Name Methylpropanoic acid

40. (a)

$n(Mg_2P_2O_7)$ = 0.0364/(24.31x2 + 2x30.97 + 16x7)

= 0.0364/222.56

= 1.63551×10^{-4} mol (1)

2 mol $MgNH_4PO_4$ → 1 mol $Mg_2P_2O_7$ (1)

$n(MgNH_4PO_4)$ = $2 \times 1.63551 \times 10^{-4}$ mol

= 3.27102×10^{-4} mol (1)

$n(MgNH_4PO_4)$ = $n(PO_4^{3-})$ in 20 mL = 3.27102×10^{-4} mol (1)

$n(PO_4^{3-})$ in 250 mL = $(3.27102 \times 10^{-4} \times 250)/20$

= 4.0888×10^{-3} mol (1)

$m(PO_4^{3-})$ = $4.0888 \times 10^{-3} \times (30.97 + 16 \times 4)$

= 0.38831 g

% = (0.38831 x 100)/6.15

= 6.31% (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(K) = 5000/39.1 = 127.88 mol

n(K) = $n(KNO_3)$= 127.88 mol (1)

$m(KNO_3)$ = 127.88(39.1 + 14.01 + 16x3)

= 12930 g

= 12.9 kg (1)

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

41.

(a) m(Cu) = 98% x 10^6 g

= 980 000 g (1)

n(Cu) = 980 000/63.55

= 15421 mol (1)

1 mol Cu → 1 mol $CuFeS_2$ (1)

15421 mol Cu → 15421 mol $CuFeS_2$ (1)

m($CuFeS_2$) = 15421 x (63.55 + 55.85 + 32.06 x 2)

= 15421 x 183.52

= 2.83 tonnes (1)

(b) n(Cu) = 15421 mol

1 mol Cu = 3 mol SO_2 (1)

15421 mol Cu = 3 x 15421 mol SO_2

= 46263 mol SO_2 (1)

150 x V(SO_2) = 46263 x 8.315 x 1773

V(SO_2) = (46263 x 8.315 x 1773)/150

= 4.55 x 10^6 L (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 BPts 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