Answers

CHAPTER 1 – Electromagnetic Spectrum

1 170 kJ mol^{-1}
2 (a) 554 nm (b) 216 kJ mol^{-1}
3 302 kJ mol^{-1}
4 (a) 650 nm (b) 184 kJ mol^{-1}
5 (a) 588 nm (b) 204 kJ mol^{-1}
6 620 nm
7 389 nm
8 405 nm
9 487 nm
10 325 nm copper

CHAPTER 2 – Volumetric Analysis

1 0.670 mol l^{-1}
2 0.184 mol l^{-1}
3 (a) 14.2 cm^3 (b) 0.142 mol l^{-1}
4 (a) 2.89 g (b) 79.4%
5 (a) 0.0917 mol l^{-1} (b) 0.409 mol l^{-1}
6 0.249 mol l^{-1}
7 1.57 mol l^{-1}
8 0.126 mol l^{-1}
9 0.0597 mol l^{-1}
10 (a) 3.60 g (b) 53.6%

CHAPTER 3 – Redox Titrations

1 50 cm^3
2 16.0 cm^3
3 (a) 33.6 cm^3 (b) 0.0269 mol (c) 2.15 mol l^{-1}
4 (a) 8.20×10^{-4} mol (b) 4.10×10^{-3} mol (c) 2.29 g (d) 92.0%
5 93.6%
6 (a) 6.20×10^{-4} mol (b) 0.620 mol l^{-1}
7 (a) 18.6 cm^3 (b) 2.23×10^{-3} mol (c) 0.0223 mol (d) 1.25 g (e) 87.1%
8 (a) 3.12×10^{-3} mol (b) 0.0156 mol (c) 1.25 mol l^{-1}
9 (a) 2.15×10^{-3} mol (b) 0.0215 mol (c) 0.859 mol l^{-1}
10 (a) 2.36×10^{-3} mol (b) 2.76 g (c) 8.52%

CHAPTER 4 – Empirical Formulae

1 SnO_2
2 CH_4
3 (a) NO_2 (b) N_2O_4
4 (a) CH_2 (b) $C_{10}H_{20}$
5 (a) Si_2H_5 (b) Si_4H_{10}
6 (a) CNH_4 (b) $C_2N_2H_8$
7 $Ca_3P_2O_8$
8 FeC_5O_5
9 $BaSO_3$
10 (a) C_3H_2I (b) $C_6H_4I_2$

CHAPTER 5 – Gravimetric Analysis

1 (a) 1.78 g (b) 35.5%
2 (a) 5.02 g (b) 79.4 %
3 (a) 0.00716 mol (b) 1.02 g (c) 5.33 g (d) 84.0%
4 (a) 1.23 g (b) 0.808%
5 (a) 5.11 g (b) 69.6%
6 (a) 0.0125 (b) 0.025 (c) 2
7 (a) 3 (b) $Cu(NO_3)_2.3H_2O$
8 (a) 10 (b) $Na_2CO_3.10H_2O$
9 (a) 6 (b) $FeSO_4.6H_2O$
10 (a) 10 (b) $Na_2SO_4.10H_2O$
11 (a) CH_2 (b) C_5H_{10}
12 (a) C_2H_4O (b) $C_4H_8O_2$
13 $C_5H_{10}O_2$
14 $C_7H_{14}O_2$
15 $C_9H_{10}O_2$

CHAPTER 6 – The Equilibrium Constant and Partition Coefficient

1 50
2 160
3 9.6
4 8
5 0.5
6 9.6×10^{-4}
7 9
8 0.735
9 0.112
10 27
11 0.794
12 (a) Ethoxyethane layer: 0.223 mol l^{-1}; aqueous layer 0.148 mol l^{-1}
(b) 0.664
13 (a) $[I_2](aq)$ = 0.0620 mol l^{-1}; $[I_2(\text{cyclohexane})]$ = 0.0930 mol l^{-1}
(b) 1.50
14 (a) 0.568 mol l^{-1} (b) 1.70 g
15 (a) 0.036 mol l^{-1} (b) 0.234 g

CHAPTER 7 – pH of Solutions and the Ionic Product of Water

1 0.699
2 7.20
3 4.42
4 0.439
5 –0.398
6 0.0269 mol l^{-1}
7 1.35×10^{-5} mol l^{-1}

8 1.58×10^{-10} mol l^{-1}
9 1.26×10^{-13} mol l^{-1}
10 1.42 mol l^{-1}
11 (a) 5.01×10^{-13} mol l^{-1} (b) 0.0200 mol l^{-1}
12 (a) 0.0348 mol l^{-1} (b) 1.46
13 (a) 1.57×10^{-14} mol l^{-1} (b) 13.8
14 (a) 1.79 mol l^{-1} (b) 5.58×10^{-15} mol l^{-1}
15 (a) 3.31×10^{-4} mol l^{-1} (b), 3.02×10^{-11} mol l^{-1}

CHAPTER 8 – Dissociation Constants and the pH of Weak Acids

1 1.34×10^{-3} mol l^{-1}
2 0.200 mol l^{-1}
3 7.21×10^{-4} mol l^{-1}
4 0.498 mol l^{-1}
5 1.47×10^{-5} mol l^{-1}
6 2.88
7 2.22
8 1.74
9 2.51
10 2.72
11 0.0513 mol l^{-1}
12 0.0871 mol l^{-1}
13 0.0537 mol l^{-1}
14 2.57×10^{-4} mol l^{-1}
15 6.31×10^{-3} mol l^{-1}
16 3.70
17 1.86
18 4.12
19 3.04
20 4.84

CHAPTER 9 – Buffer Solutions

1 5.16
2 4.43
3 4.80
4 4.87
5 4.15
6 4.46
7 3.87
8 3.60
9 5.17
10 4.46
11 Acid : salt ratio = 2.14 or salt : acid ratio = 0.468
12 Acid : salt ratio = 0.398 or salt : acid ratio = 2.51
13 Acid : salt ratio = 0.275 or salt : acid ratio = 3.63
14 Acid : salt ratio = 3.55 or salt : acid ratio = 0.282
15 Acid : salt ratio = 2.29 or salt : acid ratio = 0.437

CHAPTER 10 – Using Bond Enthalpies

1 -631 kJ mol^{-1}
2 -778 kJ mol^{-1}
3 -97 kJ mol^{-1}
4 -561 kJ mol^{-1}
5 -58 kJ mol^{-1}
6 -291 kJ mol^{-1}
7 -221 kJ mol^{-1}
8 320 kJ mol^{-1}
9 338 kJ mol^{-1}
10 -66 kJ mol^{-1}

CHAPTER 11 – Enthalpy Diagrams (Born–Haber Cycles)

1 -416 kJ mol^{-1}.

2 (a) $\Delta H_1 = 159$ kJ mol^{-1}; $\Delta H_2 = 78$ kJ mol^{-1} (using the enthalpy of atomisation of F), or 77.5 kJ mol^{-1} (using $\frac{1}{2}$ the bond enthalpy of F–F); $\Delta H_3 = 526$ kJ mol^{-1}; $\Delta H_4 = -328$ kJ mol^{-1}; $\Delta H_5 = -1030$ kJ mol^{-1}
(b) -595 kJ mol^{-1} (or -595.5 kJ mol^{-1} if $\frac{1}{2}$ the bond enthalpy of F–F, 77.5 kJ mol^{-1}, had been used instead of the enthalpy of atomisation of F)

3 (a) $\Delta H_1 = 81$ kJ mol^{-1}; $\Delta H_2 = 78$ kJ mol^{-1} (or 77.5 kJ mol^{-1}; see answer to Question 2 for explanation); $\Delta H_3 = 409$ kJ mol^{-1}; $\Delta H_4 = -328$ kJ mol^{-1}
(b) -775 kJ mol^{-1} (or -774.5 kJ mol^{-1})

4 (a) $\Delta H_1 = 147$ kJ mol^{-1}; $\Delta H_2 = 243$ kJ mol^{-1} if the bond enthalpy of Cl–Cl has been used; 242 kJ mol^{-1} if the enthalpy of atomisation of Cl has been used); $\Delta H_3 = 744$ kJ mol^{-1}; $\Delta H_4 = 1460$ kJ mol^{-1}; $\Delta H_5 = -698$ kJ mol^{-1}; $\Delta H_6 = -2326$ kJ mol l^{-1}
(b) -430 kJ mol^{-1} if the bond enthalpy of Cl–Cl has been used; or -431 kJ mol^{-1} if the enthalpy of atomisation of Cl has been used

5 (a) $\Delta H_1 = 430$ kJ mol^{-1}; $\Delta H_2 = 155$ kJ mol^{-1} if the Bond Enthalpy of F–F has been used; 156 kJ mol^{-1} if 2 × the enthalpy of atomisation of F has been used; $\Delta H_3 = 743$ kJ mol^{-1}; $\Delta H_4 = 1770$ kJ mol^{-1}; $\Delta H_5 = -656$ kJ mol^{-1}; $\Delta H_6 = -2845$ kJ mol l^{-1}
(b) -403 kJ mol^{-1} if the bond enthalpy of F–F has been used; or -402 kJ mol^{-1} if the enthalpy of atomisation of F has been used

6 (a) $\Delta H_1 = 671$ kJ mol^{-1}; $\Delta H_2 = -321$ kJ mol^{-1}; $\Delta H_3 = -337$ kJ mol^{-1}
(b) 13 kJ mol^{-1}

7 (a) $\Delta H_1 = 732$ kJ mol^{-1}; $\Delta H_2 = -405$ kJ mol^{-1}; $\Delta H_3 = -337$ kJ mol^{-1}
(b) -10 kJ mol^{-1}

8 (a) $\Delta H_1 = 834$ kJ mol^{-1}; $\Delta H_2 = -520$ kJ mol^{-1}; $\Delta H_3 = -364$ kJ mol^{-1}
(b) -50 kJ mol^{-1}

9 (a) $\Delta H_1 = 2913$ kJ mol^{-1}; $\Delta H_2 = -1920$ kJ mol^{-1}; $\Delta H_3 = -1012$ kJ mol^{-1}
(b) -19 kJ mol^{-1}

10 (a) $\Delta H_1 = 2127$ kJ mol^{-1}; $\Delta H_2 = -1480$ kJ mol^{-1}; $\Delta H_3 = -728$ kJ mol^{-1}
(b) -81 kJ mol^{-1}

CHAPTER 12 – ΔH°, ΔS° and ΔG°

1 (a) $\Delta H^\circ = 271$ kJ mol^{-1}; $\Delta S^\circ = 172$ J K^{-1} mol^{-1} or 0.172 kJ K^{-1} mol^{-1}
(b) 219 kJ mol^{-1}
(c) Above 1580 K

2 (a) $\Delta H^\circ = 166$ kJ mol^{-1}; $\Delta S^\circ = 476$ J K^{-1} mol^{-1} or 0.476 kJ K^{-1} mol^{-1}
(b) -72 kJ mol^{-1}
(c) Above 349 K

3 (a) $\Delta H^\circ = 176$ kJ mol^{-1}; $\Delta S^\circ = 285$ J K^{-1} mol^{-1} or 0.285 kJ K^{-1} mol^{-1}
(b) -109 kJ mol^{-1}
(c) Above 618 K

4 (a) $\Delta H^\circ = -92$ kJ mol^{-1}; $\Delta S^\circ = -199$ J K^{-1} mol^{-1} or -0.199 kJ K^{-1} mol^{-1}
(b) 7.50 kJ mol^{-1}
(c) Below 462 K

5 (a) $\Delta H^\circ = -882$ kJ mol^{-1}; $\Delta S^\circ = -147$ J K^{-1} mol^{-1} or -0.147 kJ K^{-1} mol^{-1}
(b) -794 kJ mol^{-1}
(c) Below 6000 K

6 (a) $\Delta H^\circ = 135$ kJ mol^{-1}; $\Delta S^\circ = 334$ J K^{-1} mol^{-1} or 0.334 kJ K^{-1} mol^{-1}
(b) -65.4 kJ mol^{-1}
(c) Above 404 K

7 (a) $\Delta H^\circ = -99$ kJ mol^{-1}; $\Delta S^\circ = -93.5$ J K^{-1} mol^{-1} or -0.0935 kJ K^{-1} mol^{-1}
(b) -71.1 kJ mol $^{-1}$
(c) Below 1060 K

8 (a) $\Delta H^\circ = -200$ kJ mol^{-1}; $\Delta S^\circ = -195$ J K^{-1} mol^{-1} or -0.195 kJ K^{-1} mol^{-1}
(b) -258.5 kJ mol^{-1}
(c) Below 1030 K

9 (a) $\Delta H^\circ = -209$ kJ mol^{-1}; $\Delta S^\circ = -367$ J mol^{-1} K^{-1} or -0.367 kJ mol^{-1} K^{-1}
(b) Below 569 K

10 (a) $\Delta H^\circ = 104$ kJ mol^{-1}; $\Delta S^\circ = 7.00$ J K^{-1} mol^{-1} or 7.00×10^{-3} kJ K^{-1} mol^{-1}
(b) 102 kJ K^{-1} mol^{-1}
(c) Above 1.49×10^4 K

CHAPTER 13 – Electrochemical Cells

1 (a) $Mg(s) \rightarrow Mg^{2+}(aq) + 2e^-$ and $Pb^{2+}(aq) + 2e^- \rightarrow Pb(s)$
(b) $Mg(s) + Pb^{2+}(aq) \rightarrow Mg^{2+}(aq) + Pb(s)$
(c) 2.24 V
(d) 432 kJ mol^{-1}

2 (a) $Ni(s) \rightarrow Ni^{2+}(aq) + 2e^-$ and $Sn^{2+}(aq) + 2e^- \rightarrow Sn(s)$
(b) $Ni(s) + Sn^{2+}(aq) \rightarrow Ni^{2+}(aq) + Sn(s)$
(c) 0.09 V
(d) -17.4 kJ mol^{-1}

3 (a) $Ni(s) \rightarrow Ni^{2+}(aq) + 2e^-$ and $Ag^+(aq) + e^- \rightarrow Ag(s)$
(b) $Ni(s) + 2Ag^+(aq) \rightarrow Ni^{2+}(aq) + 2Ag(s)$
(c) 1.03 V
(d) -199 kJ mol^{-1}

4 (a) 1.5 V
(b) 289.5 kJ mol^{-1}
5 (a) $H_2O_2(aq) + 2Fe^{2+}(aq) + 2H^+(aq) \rightarrow 2H_2O(l) + 2Fe^{3+}(aq)$
(b) 1.00 V
(c) −193 kJ mol^{-1}
6 (a) $Br_2(l) + 2e^- \rightarrow 2Br^-(aq)$ and $SO_3^{2-}(aq) + H_2O(l) \rightarrow SO_4^{2-}(aq) + 2H^+(aq) + 2e^-$
(b) $Br_2(l) + SO_3^{2-}(aq) + H_2O(l) \rightarrow 2Br^-(aq) + SO_4^{2-}(aq) + 2H^+(aq)$
(c) 0.90 V
(d) −174 kJ mol^{-1}
7 (a) −0.74 V
(b) Cr
(c) $3Mg(s) + 2Cr^{3+}(aq) \rightarrow 3Mg^{2+}(aq) + 2Cr(s)$
(d) −944 kJ mol^{-1}
8 (a) 2.05 V
(b) −396 kJ mol^{-1}
9 (a) $O_2(g) + 2H_2O(l) + 4e^- \rightarrow 4OH^-(aq)$ and $H_2(g) + 2OH^-(aq) \rightarrow 2H_2O(l) + 2e^-$
(b) $2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$
(c) 1.23 V
(d) −237 kJ mol^{-1}
10 (a) 0.46 V
(b) −88.8 kJ mol^{-1}
(c) −108 J K^{-1} mol^{-1} (or −0.108 kJ mol^{-1})

CHAPTER 14 – Rate Equations

1 (a) rate = k[A] (b) 0.1 s^{-1}
2 (a) rate = k[X][Y] (b) 0.2 mol^{-1} l min^{-1}
3 (a) rate = $k[B]^2$ (b) 2 mol^{-1} l s^{-1}
4 (a) rate = $k[X]^2[Y]$ (b) 0.5 mol^{-2} l^2 min^{-1}
5 (a) rate = $k[Y]^2[Z]$ (b) 2 mol^{-2} l^2 min^{-1}
6 (a) rate = k[X][Y] (b) 8 mol^{-1} l s^{-1}
7 (a) rate = k[A][C] (b) 20 mol^{-1} l min^{-1}
8 (a) rate = $k[Y]^2[Z]$ (b) 150 mol^{-2} l^2 min^{-1}
9 (a) rate = k[X][Z] (b) 0.375 mol^{-1} l s^{-1}
10 (a) rate = $k[B]^2$ (b) 48 mol^{-1} l s^{-1}

PRESCRIBED PRACTICAL ACTIVITIES

PPA 1
90.2%

PPA 2
(a) $Mn(s) \rightarrow Mn^{2+}(aq) + 2e^-$
(b) $Mn^{2+}(aq) + 4H_2O(l) \rightarrow MnO_4^-(aq) + 8H^+(aq) + 5e^-$
(c) 0.034 mol l^{-1}
(d) 0.187 g
(e) 22.1%

PPA 3
(a) (i) 2.935×10^{-3} mol
(ii) 0.0117 mol
(iii) 0.689 g
(iv) 24.7%
(b) (iii) $NiCl_2.6H_2O$

PPA 4
(a) 0.0108 mol
(b) 0.0233 mol
(c) 2 (to the nearest whole number)

PPA 5
(a) Aqueous layer = 0.01 mol l^{-1};
cyclohexane layer = 0.015 mol l^{-1}
(b) 1.5

Note that the calculation of the partition coefficient did not need the actual concentrations of the iodine in the two layers. Since the same volume of each layer had been titrated with the same thiosulphate solution, the ratio of the volumes of the titres (15/10) gives the partition coefficient for the equilibrium described by the equation given.

PPA 6
Problem 1
(a) $\Delta H° = 135$ kJ mol^{-1};
$\Delta S° = 334$ J K^{-1} mol l^{-1} (or 0.334 J K^{-1} mol^{-1})
(b) Above 404 K
Problem 2
0.630 g

PPA 7
(a) 8.33×10^{-6} mol l^{-1} s^{-1}
(b) 4.17×10^{-5} mol^{-1} l s^{-1}

PPA 8
64.8%

PPA 10
60.0%

PPA 11
75%

PPA 12
(a) 0.025 mol
(b) 1.59×10^{-3} mol
(c) 1.59×10^{-3} mol
(d) 0.0159 mol
(e) 9.10×10^{-3} mol
(f) 4.55×10^{-3} mol
(g) 0.819 g
(h) 78.75%