SCH4U– FINAL UNIT REVIEW – Answers

THERMOCHEMISTRY

1. a) Q = 33.45 KJ
= 3.345 x 10^4 J

M = 244.0 g

$\Delta T = T_2 - T_1$
$= 70.9 - 31.8\ ^0C$
$= 39.1\ ^0C$

$$c = \frac{Q}{m\Delta T}$$
$$= \frac{3.345\times 10^4 J}{(244.0g)(39.1^oC)}$$
$$= 3.506\, J/g^oC$$

$$\therefore c = 3.506\, J/g^oC$$

b)

$$c_p{}^o = C.M$$
$$= (3.506\frac{J}{g^oC})(27.0\frac{g}{mol})$$
$$= 94.67\, J/mol^oC$$

$$\therefore c_p{}^o = 94.7\, J/mol^oC$$

2. a) $C_8H_8\,(g) + 25\ O_2\,(g) \rightarrow 16\ CO_2\,(g) + 18\ H_2O\,(l)$

b)

$$\Delta H^o = \Delta H^o{}_{f(p)} - \Delta H^o{}_{f(R)}$$
$$-4597 = [16(-393.5) + 18(-285.8)] - [2x + 25(0.0)]$$
$$-4597 = -11440.4 - 2x$$
$$x = -3421.7$$
$$\Delta H^o{}_f = -3422\ kJ$$

3.

	ΔH_f^0 (kJ)
$Fe_2O_3(s) \rightarrow 2\,FeO(s) + \frac{1}{2}\,O_2(g)$	$-\frac{1}{2}$ (-560.4)
$2\,FeO(s) \rightarrow 2\,Fe(s) + O_2(g)$	+1 (+ 544.0)
$3\,CO(g) \rightarrow 3\,C(s) + 3/2\,O_2(g)$	+ 3/2 (+ 221.0)
$3\,C(s) + 6\,H_2(g) \rightarrow 3\,CH_4(g)$	-3 (+74.8)
$3\,CH_4(g) + 6\,O_2(g) \rightarrow 3\,CO_2(g) + 6\,H_2O(g)$	+3 (- 371.5)
$6\,H_2O(g) \rightarrow 6\,H_2(g) + 3\,O_2(g)$	-3 (-241.6)
$Fe_2O_3(s) + 3\,CO(g) \rightarrow 2\,Fe(s) + 3\,CO_2(g)$	+ 541.6

$\therefore \Delta H_f^0 = +542$ kJ

4. a) $\Delta H < 0$ & $\Delta S > 0$
ie. Minimum enthalpy & maximum entropy

b) (i) $\Delta H > 0$ $\therefore$ tend toward inc. enthalpy
$\therefore$ does NOT favour spontaneity

(ii $\Delta S > 0$ $\therefore$ tend toward inc entropy

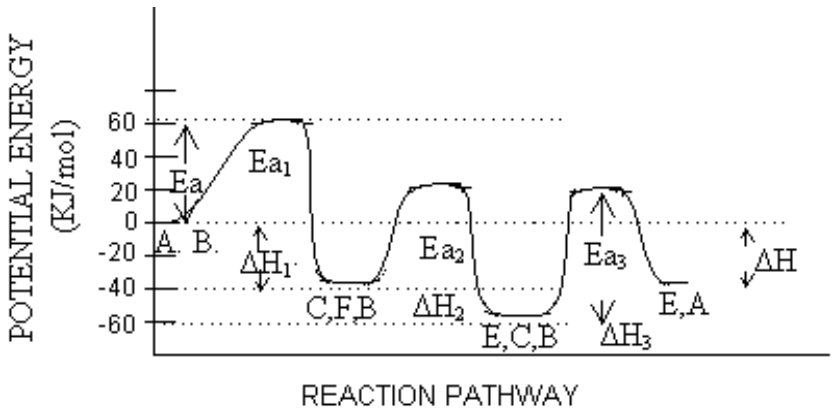
(More moles gas on product side)
$\therefore$ favour spontaneity

5. (i) a) is exothermic
(ii) a) is fastest, since lowest Ea

RATE OF REACTION

1. a) Temperature, concentration of reactants
Nature of reactants, presence of catalyst
Theory

2. a)



b) $3B \xrightarrow{A} 2E$

c) $\Delta H = -41\ kJ$

d) Rate Determining Step is step III, largest Ea

e) C and F

f) A

g) Steps I & II are exothermic

h) (i) C.p. II
(ii) C.p. III
(iii) C.p. I

4. a) 1st order
b) zero order
c) 1st order
d) Rate = K [$C_4H_{11}CF$]

e) $k = \dfrac{5.5\times10^{-4}\ mol/L/s}{0.10\ mol/L}$

$= 5.5\times10^{-3}\ s^{-1}$

f) molecularity is 2 or bimolecular

CHEMICAL EQUILIBRIUM

1.

$a)\quad Kc = \dfrac{[H_2O]}{[CO][H_2]}$

$b)\quad Kc = \dfrac{5.4\times10^{-4}}{(3.2\times10^{-3})(2.5\times10^{-4})}$

$Kc = 675$

2.

$a)\quad Kc = \dfrac{[Na^+]}{[H^+]}$

$b)\quad Kc = [Al^{3+}]^2\,[SO_4{}^{2-}]^3$

3. a) same as physical or chemical change
b) (i) homogeneous
(ii) heterogeneous

4. A) $Keq = \dfrac{[C]^3[D]}{[A]^2[B]}$

b)

	[A]	[B]	[C]	[D]
	(mol/L)	(mol/L)	(mol/L)	(mol/L)
Initial	1.75	1.75	_____	_____
Change	-0.433	-0.217	0.65	0.217
Equilibrium	1.317	1.533	0.65	0.217

$Keq = \dfrac{(0.65)^3(0.217)}{(1.317)^2(1.533)}$

$= 0.02241$

$Keq = 2.24\times10^{-2}$

5. Low temperature
Low volume
High pressure
dec $[NH_3]$
inc $[N_2]$ or $[H_2]$

6.

	$[N_2]$	$[O_2]$	[NO]
	(mol/L)	(mol/L)	(mol/L)
Initial	0.1375	0.0875	---------
Change	- x	-x	x
Equilibrium	0.1375 - x	0.0875 - x	x

Let x rep $[NO]_{equilibrium}$ in mol/L

$$Kc = \frac{[NO]}{[N_2][O_2]} \qquad \because Kc < 1.0 \times 10^{-3}$$

$$\therefore 0.1375 >> x$$

$$2.51 \times 10^{-7} = \frac{x}{(0.1375 - x)(0.0875 - x)}$$

$$2.51 \times 10^{-7} = \frac{x}{(0.1375)(0.0875)}$$

$$x = 3.0198 \times 10^{-9}$$

$$[NO] = 3.02 \times 10^{-9}\, mol / L$$

$$[N_2] = 0.138\, mol / L$$

$$[O_2] = 8.75 \times 10^{-2}\, mol / L$$

SOLUBILITY EQUILIBRIUM

1.

a) $2\ K_3PO_4(aq) + 3\ Mg(NO_3)_2(aq) \rightarrow Mg_3(PO_4)_2(s) + 6\ KNO_3$

b) $6K^+(aq) + 2\ PO_4^{3-}(aq) + 3\ Mg^{2+}(aq) + 6\ NO_3^-(aq) \rightarrow Mg_3(PO_4)_2(s) + 6\ K^+(aq) + 6\ NO_3^-(aq)$

c) $3\ Mg^{2+}(aq) + 2\ PO_4^{3-}(aq) \rightarrow Mg_3(PO_4)_2(s)$

d) $Mg_3(PO_4)_2(s) \rightarrow 3\ Mg^{2+}(aq) + 2\ PO_4^{3-}(aq)$

e) $Ksp = [Mg^{2+}]^3\,[PO_4^{3-}]^2$

2. $CaCO_3(s) \rightleftarrows Ca^{2+}(aq) + CO_3^{2-}(aq)$

$Ksp = [Ca^{2+}][CO_3^{2-}]$ Let x represent $[Ca^{2+}]$ in mol/L

$8.7 \times 10^{-9} = (x)(x)$

$x = 9.33 \times 10^{-5}$

$[Ca^{2+}] = 9.33 \times 10^{-5}$ mol/L

$= 9.3 \times 10^{-6}$ mol/100 mL

3. $Ag_2CrO_4(s) \rightarrow 2\,Ag^+(aq) + CrO_4^{2-}(aq)$

$Ksp = [Ag^+]^2[CrO_4^{2-}]$ Let x represents $[CrO_4^{2-}]$ in mol / L

$5.02\times10^{-13} = (2x)^2(x)$ Thnn 2x represents $[Ag^+]$ in mol / L

$5.02\times10^{-13} = 4x^3$ Then x represents $[Ag_2CrO_4]$ in mol / L

$x = 5.007\times10^{-5}$

$[Ag_2CrO_4] = 5.007\times10^{-5}\ mol/L \qquad m = n.M$

$= (5.007\times10^{-5}\ mol)(331.8\ g/mol)/L$

$= 1.661\times10^{-2}\ g/L$

$\therefore$ Solubility *is* $1.66\times10^{-2}\ g/L$

4.

$$[Ca(NO_3)_2] = \frac{50.0\,mL}{200.0\,mL}\times 0.0420\,mol/L$$

$$= 0.0105 \quad mol/L$$

$$[Ca^{2+}] = 0.0105\,mol/L$$

$$[(NH_4)_2SO_4] = \frac{150.0\,mL}{200.0\,mL}\times 0.00810\,mol/L$$

$$= 0.006075 \quad mol/L$$

$$[SO_4^{2-}] = 0.006075\,mol/L$$

$$TRIAL\ Kps = [Ca^{2+}][SO_4^{2-}]$$

$$= (0.0105)(0.006075)$$

$$= 6.379\times10^{-5}$$

$TRIAL\ Ks < ACTUAL\ Ksp$

$6.379\times10^{-5} < 2.61\times10^{-4}$

$\therefore$ *precipitate will NOT form*

5. $BaF_2(s) \rightarrow Ba^{2+}(aq) + 2\,F^-(aq)$
$Ba(NO_3)_2(aq) \rightarrow Ba^{2+}(aq) + 2\,NO_3^-(aq)$

common ion Ba^{2+}

$Ksp = [Ba^{2+}][F^-]^2$

$1.71\times10^{-6} = (0.750)[F^-]^2$

$[F^-]^2 = 2.28\times10^{-6}$

$[F^-] = 1.51\times10^{-3}\ mol/L$

IONIC EQUILIBRIUM

1. H_2PO_4 - strongest, most number of oxygens in the formula

2.

	ACID	BASE
ARRHENIUS	Free H^+ in H_2O	Free OH^- in H_2O
BRONSTED	H^+ donor	H^+ acceptor
LEWIS	e^- pair acceptor	e^- pair donor

3. a) Na^+ would NOT hydrolyze
∵ NaOH strong base

$C_2H_3O_2$ would hydrolyse to form a <u>base</u>
∵ $HC_2H_3O_2$ weak acid

b) basic

4.

$$CH_3COOH(aq) + H_2O_{(l)} \rightleftharpoons H_3O^+(aq) + CH_3COO^-(aq)$$

	$[CH_3COOH]$	$[H^+]$	$[CH_3COO^-]$
	(mol/L)	(mol/L)	(mol/L)
Initial	0.0020	---------	-----
Change	-0.056×0.002	0.056×0.002	0.056×0.002
Equilibrium	1.89×10^{-3}	1.12×10^{-4}	1.12×10^{-4}

$$Ka = \frac{[H^+][CH_3CO_2^-]}{[CH_3CO_2H]}$$

$$= \frac{(1.12\times10^{-4})(1.12\times10^{-4})}{1.89\times10^{-3}}$$

$$= 6.64\times10^{-6}$$

5.

$$[H^+]_i = \frac{17.5\,mL}{28.0\,mL} \times 0.20\,mol/L$$

$$= 0.125\,mol/L$$

$$[OH^-]_i = \frac{10.5\,mL}{28.0\,mL} \times 0.12\,mol/L$$

$$= 0.045\,mol/L$$

$$[H^+] = [H^+]_i - [OH^-]_i$$

$$= 0.125 - 0.045\,mol/L$$

$$= 0.0800\,mol/L$$

$$pH = 1.10$$

$$pOH = 12.9$$

$$[OH^-] = 1.25 \times 10^{-13}\,mol/L$$

6.

$$[HF] = \frac{m/M}{V}$$

$$= \frac{39.98\ \text{g} \Big/ 20.0\ {}^{\text{g}}\!\!\diagup\!\!{}_{\text{mol}}}{5.00\ \text{L}}$$

$$= 3.998 \text{mol/L}$$

	[HF]	$[H_3O^+]$	$[F^-]$
	(mol/L)	(mol/L)	(mol/L)
Initial	3.998	---------	---------
Change	- x	x	x
Equilibrium	3.998 - x	x	x

Let x rep $[H_3O^+]$ in mol/L

$$Ka = \frac{[H^+][F^-]}{[HF]}$$

$$2.56 \times 10^{-4} = \frac{(x)(x)}{3.998 - x}$$

$$x = 9.9896 \times 10^{-3}$$

$$[H^+] = 9.99 \times 10^{-3}\ mol/L$$

OXIDATION & REDUCTION

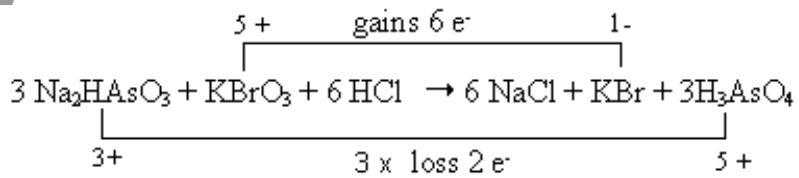
1.
a)

b) NO_3^- → NO

2($NO_3^- + 4\ H^+ + 3\ e^-$ → $NO + 2\ H_2O$)
(ii) (iii) (i)

SO_2 → SO_4^{2-}

3($SO_2 + 2\ H_2O$ → $SO_4^{2-} + 4\ H^+ + 2\ e^-$)
(i) (ii) (iii)



$2\ NO_3^- + 8\ H^+ + 6\ e^-$ → $2\ NO + 4\ H_2O$

$3\ SO_2 + 6\ H_2O$ → $3\ SO_4^{2-} + 12\ H^+ + 6\ e^-$

$2\ NO_3^- + 3\ SO_2 + 2\ H_2O$ → $2\ NO\ \ 3\ SO_4^{2-} + 4\ H^+$

c)

Mn^{2+} → MnO_4^-

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

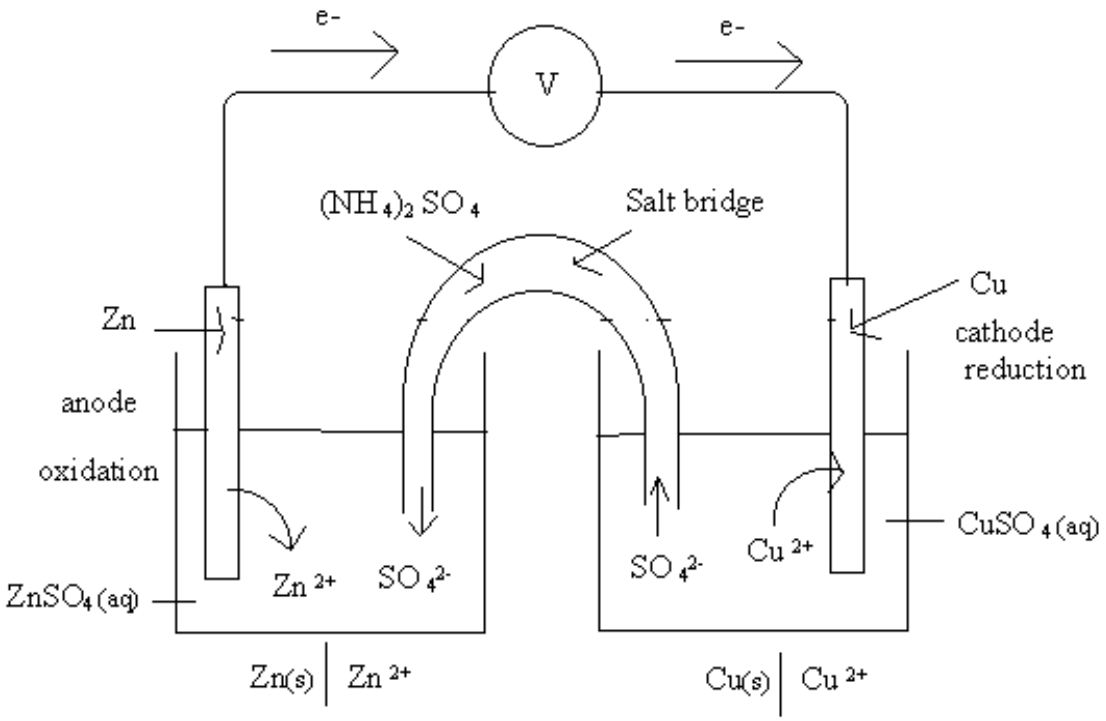
5 ($H_2O_2 + 2\ H^+ + 2\ e^-$ → $2\ H_2O$)

$2\ Mn^{2+} + 8\ H_2O$ → $2\ MnO_4^- + 16\ H^+ + 10\ e^-$

$5\ H_2O_2 + 10\ H^+ + 10\ e^-$ → $10\ H_2O$

$5\ H_2O_2 + 2\ Mn^{2+}$ → $2\ MnO_4^- + 6\ H^+ + 2\ H_2O$

2a



b) (i) Anode

$Zn_{(s)} \rightarrow Zn^{2+} + 2e^-$ $\quad$ E^o: $-(-0.76\ V)$

(ii) Cathode

$Cu^{2+} + 2e^- \rightarrow Cu_{(s)}$ $\quad$ $+(+0.34\ V)$

(iii) $Cu^{2+} + Zn_{(s)} \rightarrow Cu + Zn^{2+}$ $\quad$ 1.10 V

c)

(i) Zn (s)

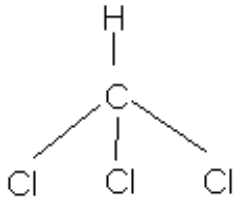
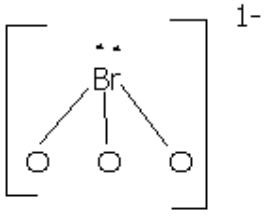
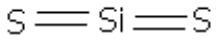
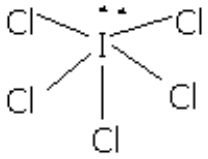
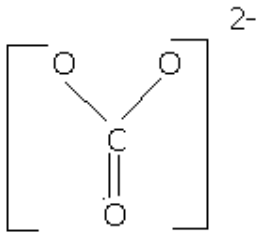
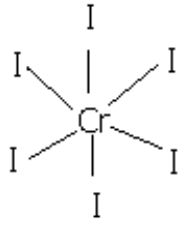
(ii) Zn (s)

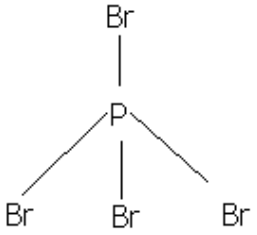
d) + 1.10 V $\quad$ (e) $Zn_{(s)} \mid Zn^{+2}_{(aq)}\ (1M) \parallel Cu^{+2}_{(aq)}\ (1M) \mid Cu_{(s)}$

BONDING & SHAPES

1c) Bent

2.

$CHCl_3$		tetrahedral	N.P.
BrO_3^-		(Trigonal) pyramidal	P.
SiS_2		linear	N.P.
ICl_5		square based pyramid	P.
CO_3^{2-}		trigonal planar (note: Resonance structure)	P
CrI_6		octahedral	N.P.

PBr_4^+		tetrahedral	P

3. a) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$

   b) outermost orbital is a 'p' orbital, s^2p^5

4. a) 16

   b) ends in s^1 after a p^6

5. Na^+ or Ne or F^-

6. a) non-polar, tetrahedral all polar forces cancel

   b) individual bond polar forces that do not cancel.