**IBHL Energetics Review**

1. $H_2O_{(s)} \rightarrow H_2O_{(l)}$ ΔH(+) ΔS(+)

When ice melts at its normal melting point, 273.16 K and 1 atmosphere, which of the following is true for the process shown above? ↓ spontaneous at low temp

A. $\Delta H < 0, \Delta S > 0, \Delta G > 0$
B. $\Delta H > 0, \Delta S < 0, \Delta G < 0$
C. $\Delta H > 0, \Delta S > 0, \Delta G < 0$
D. $\Delta H < 0, \Delta S < 0, \Delta G > 0$

2. Which statement about bonding is correct?

A. Bond breaking is endothermic and requires energy.
B. Bond breaking is endothermic and releases energy.
C. Bond making is exothermic and requires energy.
D. Bond making is endothermic and releases energy.

3. $\Delta G^\theta$ calculations predict that a reaction is always spontaneous for which of the following combinations of $\Delta H^\theta$ and $\Delta S^\theta$?

A. $+\Delta H^\theta$ and $+\Delta S^\theta$
B. $+\Delta H^\theta$ and $-\Delta S^\theta$
C. $-\Delta H^\theta$ and $-\Delta S^\theta$
D. $-\Delta H^\theta$ and $+\Delta S^\theta$ exo less ordered = ΔG-

ΔG = (-#) - T(+#) → really

4. Consider the following reactions.

$$Cu_2O(s) + \frac{1}{2}O_2(g) \rightarrow 2CuO(s) \qquad \Delta H^\theta = -144 \text{ kJ}$$

$$Cu_2O(s) \rightarrow Cu(s) + CuO(s) \text{ reverse} \qquad \Delta H^\theta = +11 \text{ kJ} \quad -111 \text{ kJ}$$

What is the value of $\Delta H^\theta$, in kJ, for this reaction?

$$Cu(s) + \frac{1}{2}O_2(g) \rightarrow CuO(s)$$

A. −144 + 11
B. +144 − 11
C. −144 − 11
D. +144 + 11

5. Which reaction has the greatest increase in entropy?

A. $SO_2(g) + 2H_2S(g) \rightarrow 2H_2O(l) + 3S(s)$ (g → s) ΔS↓
B. $CaO(s) + CO_2(g) \rightarrow CaCO_3(s)$ (more moles → less) ↓
C. $CaC_2(s) + 2H_2O(l) \rightarrow Ca(OH)_2(s) + C_2H_2(g)$ l → g
D. $N_2(g) + O_2(g) \rightarrow 2NO(g)$ (2 moles → 2 moles) ΔS≈0

6. Some words used in chemistry can have a specific meaning which is different to their meaning in everyday English. State what the term *spontaneous* means when used in a chemistry context.

ΔG(-) → a rxn that occurs w/out adding energy

7. Propane can be formed by the hydrogenation of propene.

$$CH_3CH{=}CH_2(g) + H_2(g) \rightarrow CH_3CH_2CH_3(g)$$

(i) State the conditions necessary for the hydrogenation reaction to occur. (remains from T10) (2)
nickel / platinum / palladium 150-200°C / heat

(ii) Enthalpy changes can be determined using average bond enthalpies. Define the term *average bond enthalpy*. (2)

· the enthalpy change when 1 mole of gaseous bond is broken / formed

· avg for same bond in a number of similar cmpds

7. iii) $1(C-C) + 1(C=C) + 6(C-H) + (H-H) + 2(C-C) + 8(C-H)$

$1(+346) + 1(+614) + 6(+414) + (+436) + 2(-346) + 8(-414)$

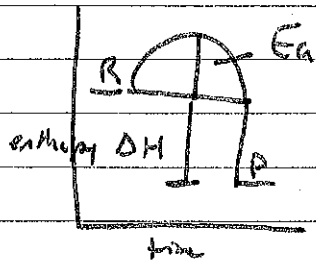
$= -124$ kJ mol$^{-1}$

iv) due to relative strength of C-C & C-H bonds compared to the C=C & H-H bonds

or

bonds in products stronger than bonds in reactants

v)




exothermic

reactants

bonds formed

8. $\Delta H_f$ : $2\,Na(s) + \frac{1}{2}O_2(g) \rightarrow 1\,Na_2O(s)$

9. a) $LiCl(s) \rightarrow Li^+(g) + Cl^-(g)$

b) a) +519

b) +1607

c) -349

d) ½ (242)

e) -408.7

c) $\Delta H_{lat} = \Delta H_{atom} + \frac{1}{2}E + \Delta H_i + \Delta H_e - \Delta H_f$

$= +1607 + \frac{1}{2}(+242) + 519 + (349) - (-409.7)$

$= +860.4$ kJ mol$^{-1}$

9. d. i) ii
ii) v
iii) iv
iv) iii
v) i

e. Higher → both carry +2/-2 charge vs. +1/-1
∴ ↑ attraction ↑ enthalpy

10. a) ii. 80.557 - 80.034 = 0.523 g

iii. $\frac{0.523}{32.04}$ = 0.0164 mols

iv. $q = mc\Delta T$
$= (20.000)(4.18)(26.4 - 21.5)$
$= +409.6\ J \rightarrow +0.4096\ kJ$

v. $-0.4096\ kJ$

vi. $\frac{-0.4096}{0.0164} = -25.1\ kJ\ mol^{-1}$ (s.f.)

b) heat loss to atmosphere, not closed system

11. a) $\Delta H_f = \Sigma \Delta H_p - \Sigma \Delta H_r$

$= 3(-394) - 2(-824)$

$= +461 \text{ kJ mol}^{-1}$

b) $\Delta S = \Sigma \Delta S_p - \Sigma \Delta S_r$

$= [4(27.8) + 3(213.7)] - [2(87.4) + 3(5.7)]$

$= 560.4 \text{ J K}^{-1} \text{ mol}^{-1}$ $0.5604 \text{ kJ K}^{-1} \text{ mol}^{-1}$

c) $\Delta G = \Delta H - T\Delta S$

$= (+461) - (298)(+0.5604)$

$= +299 \text{ kJ mol}^{-1}$

d) NO, positive $\Delta G$

e) $0 = \Delta H - T\Delta S$

$T = \frac{\Delta H}{\Delta S} \quad \frac{461}{0.5604} = 831 \text{ K}$ or $558\ ^\circ\text{C}$

12. $\Delta H_{soln} = \Delta H_{lat}(SrCl_2) + \Delta H_{hyd}(Sr^{2+}) + \Delta H_{hyd}(2Cl^-)$

$= (+2170) + (-1483) + 2(-359)$

$= -31 \text{ kJ mol}^{-1}$