Topic 17 / Review 2019 *[11 marks]*

Key

1. 1.0 mol of $N_2(g)$, 1.0 mol of $H_2(g)$ and 1.0 mol of $NH_3(g)$ are placed in a 1.0 dm^3 sealed flask and left to reach equilibrium. At equilibrium the concentration of $N_2(g)$ is 0.8 mol dm^{-3}. *[1 mark]*

   $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

   What are the equilibrium concentration of $H_2(g)$ and $NH_3(g)$ in mol dm^{-3}?

	$[H_2(g)]$ / mol dm^{-3}	$[NH_3(g)]$ / mol dm^{-3}
A.	0.2	1.2
(B.)	0.4	1.4
C.	0.4	0.4
D.	0.8	1.2

$1N_2 + 3H_2 \rightleftharpoons 2NH_3$

N_2	H_2	NH_3
1.0	1.0	1.0
−0.2	−0.6	+0.4
0.8	0.4	1.4

2. At 700 ºC, the equilibrium constant, K_c, for the reaction is 1.075×10^8. > 1 *[1 mark]*

   $2H_2(g) + S_2(g) \rightleftharpoons 2H_2S(g)$

   Which relationship is always correct for the equilibrium at this temperature?

   A. $[H_2S]^2 < [H_2]^2[S_2]$

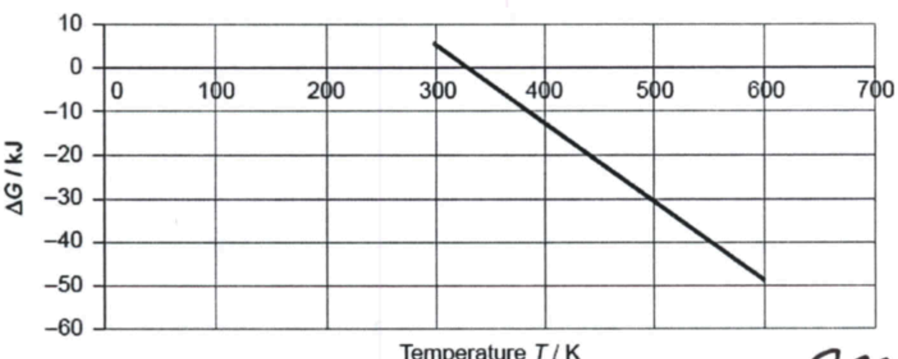
   B. $[S_2] = 2[H_2S]$

   C. $[H_2S] < [S_2]$

   (D.) $[H_2S]^2 > [H_2]^2[S_2]$

$$K_c = \frac{[H_2S]^2}{[H]^2[S_2]} > 1$$

3. The graph shows values of ΔG for a reaction at different temperatures. *[1 mark]*



Which statement is correct?

A. The standard entropy change of the reaction is negative.

(B.) The standard enthalpy change of the reaction is positive.

C. At higher temperatures, the reaction becomes less spontaneous.

D. The standard enthalpy change of the reaction is negative.

Spontaneity increases at higher temperatures. $\therefore \Delta S = (+)$

Recall,

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

$(-) = (+) - T(+)$

4. Components X and Y are mixed together and allowed to reach equilibrium. The concentrations of X, Y, W and Z in the equilibrium mixture are 4, 1, 4 and 2 mol dm^{-3} respectively. *[1 mark]*

$X + 2Y \rightleftharpoons 2W + Z$

What is the value of the equilibrium constant, K_c?

A. $\frac{1}{8}$

B. $\frac{1}{2}$

C. 2

D. 8

$$K_c = \frac{[W]^2[Z]}{[X][Y]^2} = \frac{(4)^2(2)}{(4)(1)} = 8$$

5. Which is correct for an isolated system in equilibrium? *[1 mark]*

	Gibbs free energy	Entropy
A.	maximum	maximum
B.	maximum	minimum
C.	minimum	maximum
D.	minimum	minimum

$\Delta G = -RT \ln K_c$

see p56 of the study guide!

6. A mixture of 0.40 mol of CO (g) and 0.40 mol of H_2 (g) was placed in a 1.00 dm^3 vessel. *[1 mark]* The following equilibrium was established.

$CO (g) + 2H_2 (g) \rightleftharpoons CH_3OH (g)$

At equilibrium, the mixture contained 0.25 mol of CO (g). How many moles of H_2 (g) and CH_3OH (g) were present at equilibrium?

	Equilibrium mol of H_2	Equilibrium mol of CH_3OH
A.	0.25	0.15
B.	0.50	0.25
C.	0.30	0.25
D.	0.10	0.15

CO	$+ 2H_2$	$\rightleftharpoons CH_3OH$
0.40	0.40	0
−0.15	−0.30	+0.15
0.25	0.10	0.15

7. The equation for the reaction between two gases, A and B, is: *[1 mark]*

$$2A(g) + 3B(g) \rightleftharpoons C(g) + 3D(g)$$

When the reaction is at equilibrium at 600 K the concentrations of A, B, C and D are 2, 1, 3 and 2 mol dm^{-3} respectively. What is the value of the equilibrium constant at 600 K?

A. $\frac{1}{6}$

B. $\frac{9}{7}$

C. 3

D. 6

$$K_c = \frac{[C][D]^3}{[A]^2[B]^3} = \frac{(3)(2)^3}{(2)^2(1)^3} = 6$$

8. A mixture of 2.0 mol of H_2 and 2.0 mol of I_2 is allowed to reach equilibrium in the gaseous state at a certain temperature in a $1.0\ dm^3$ flask. At equilibrium, 3.0 mol of HI are present. What is the value of K_c for this reaction? *[1 mark]*

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$

2.0 2.0 0
−1.5 −1.5 +3.0
0.5 0.5 3.0

$K_c = \frac{(3.0)^2}{(0.5)(0.5)}$

A. $K_c = \frac{(3.0)^2}{(0.5)^2}$

B. $K_c = \frac{3.0}{(0.5)^2}$

C. $K_c = \frac{(3.0)^2}{(2.0)^2}$

D. $K_c = \frac{(0.5)^2}{(3.0)^2}$

9. What is the relationship between pK_a, pK_b and pK_w for a conjugate acid–base pair? *[1 mark]*

A. $pK_a = pK_w + pK_b$

B. $pK_a = pK_w - pK_b$

C. $pK_a \times pK_b = pK_w$

D. $\frac{pK_a}{pK_b} = pK_w$

(I know... off topic!)

10. When gaseous nitrosyl chloride, NOCl (g), decomposes, the following equilibrium is established: *[1 mark]*

$$2NOCl(g) \rightleftharpoons 2NO(g) + Cl_2(g)$$

2.0 mol of NOCl(g) were placed in a $1.0\ dm^3$ container and allowed to reach equilibrium. At equilibrium 1.0 mol of NOCl(g) was present. What is the value of K_c?

A. 0.50

B. 1.0

C. 1.5

D. 2.0

$2NOCl \rightleftharpoons 2NO + Cl_2$
2.0 0
−1.0 +1.0 +0.5
1.0 1.0 0.5

$K_c = \frac{(1.0)^2(0.5)}{1.0}$

11. The indicator, HIn is used in a titration between an acid and base. Which statement about the dissociation of the indicator, HIn is correct? *[1 mark]*

$$HIn(aq) \rightleftharpoons H^+(aq) + In^-(aq)$$

colour A colour B

A. In a strongly alkaline solution, colour B would be observed.

B. In a strongly acidic solution, colour B would be observed.

C. $[In^-]$ is greater than [HIn] at the equivalence point.

D. In a weakly acidic solution colour B would be observed.

Removes H^+ ($OH^- + H^+ \rightarrow H_2O$) ∴ shifts right