Equilibrium Problems Answers

8. $N_2O_4(g) \rightleftharpoons 2NO_2(g) \quad \Delta H° = +59\ kJ$

a) S: ↑ heat energy

R: ↓ heat energy

H: endothermic reactions

D: shift right

E: ↓ $[N_2O_4(g)]$

b) S: ↓ pressure

R: ↑ pressure

H: make more moles of gas

D: shift right

E: ↓ $[N_2O_4(g)]$

c) S: ↑ $[NO_2(g)]$

R: ↓ $[NO_2(g)]$

H: use up $NO_2(g)$

D: shift left

E: ↑ $[N_2O_4(g)]$

d) addition of He will have no effect

- He is not a part of the equilibrium
- even though, total pressure will increase, the partial pressures of the gases at equilibrium will not change (partial pressure is not altered by addition of a different gas and in fact pressure changes really are concentration changes!!!)

e) addition of a catalyst will have no effect on equilibrium position but will decrease the time required for equilibrium to be reached in the first place

9. $H_2(g) + \frac{1}{2}O_2(g) \rightleftharpoons H_2O(g) \quad \Delta H° = -238$ kJ

a) S: ↑ heat energy

R: ↓ heat energy

H: endothermic reactions

D: shift left

E: ↓ $[H_2O(g)]$

b) S: ↓ pressure

R: ↑ pressure

H: make more moles of gas

D: shift left

E: ↓ $[H_2O(g)]$

d) same as above

e) same as above

10.

a) $4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g)$ $\Delta H° = -903$ kJ

consider temperature

D: shift to the right

H: exothermic reaction

R: ↑ Q

S: ↓ Q

therefore reduce the temperature

consider pressure

D: shift to the right

H: make more moles of gas

R: ↑ P

S: ↓ P

therefore reduce the pressure

b) $Br_2(g) + Cl_2(g) \rightleftharpoons 2BrCl(g)$ $\Delta H° = 14.6$ kJ

consider temperature

D: shift to the right

H: endothermic reaction

R: ↓ Q

S: ↑ Q

therefore increase the temperature

consider pressure: Since this reaction is equimolar with respect to moles of gas, pressure will not be able to have any effect on equilibrium position

c) $BaSO_4(s) \rightleftharpoons Ba^{2+}(aq) + SO_4^{2-}(aq)$ $\Delta H° = 24.244$

consider temperature

D: shift to the right

H: endothermic reaction

R: $\downarrow$ Q

S: $\uparrow$ Q

therefore increase the temperature

consider pressure: Since no gases are present in this reaction, virtually no volume change will occur during a reaction and hence pressure has no effect on the equilibrium position.

11.

a) $$K_{eq} = \frac{[HF(g)]^2}{[H_2(g)][F_2(g)]}$$

b) $$K_{eq} = \frac{[N_2O_5(g)]^2}{[NO(g)]^4[O_2(g)]^3}$$

c) $$K_{eq} = [CO_2(g)]$$

d) $$K_{eq} = [H_2O(g)]^9$$

12. Answer is based on the fact that K_{eq} values are based on product concentration over reactant concentrations. Therefore:

- if $K_{eq} = 1.5 \times 10^{12}$ reactants <<< products
- if $K_{eq} = 0.15$ reactants > products
- if $K_{eq} = 4.3 \times 10^{-15}$ reactants >>> products

Therefore:

a) products over reactants ratio is large for the first example

b) products over reactants ratio is small for the last example

13. $Br_2(l) \rightleftharpoons Br_2(g)$ $\Delta H° = +$ as written (i.e. particles further apart, must overcome attractive forces)

$K_{eq} = [Br_2(g)]$

S: ↑ Q

R: ↓ Q

H: endothermic reaction (use up heat)

D: Shifts to the right

E: ∴ ↑ $[Br_2(g)]$, ∴ ↑ K_{eq} i.e $K_{eq} = [Br_2(g)]$

therefore if $[Br_2(g)]$ goes up the K_{eq} will increase as well

15. $CO(g) + Cl_2(g) \rightleftharpoons COCl_2(g)$ $\Delta H° = -$ as written (i.e. particles are getting closer together

a) 15 s

b)

$$K_{eq} = \frac{[COCl_2(g)]}{[CO(g)][Cl_2(g)]}$$

$$K_{eq} = \frac{[0.8]}{[1.7][0.7]}$$

$$K_{eq} = 0.672$$

Please note that units are not required for any part of the this type of calculation.

c) Injection of CO (only an injection would cause an abrupt increase in concentration.

d) Is most likely a change in temperature (could verify this by seeing if the K_{eq} value is different after equilibrium is re-established).

e) Yes - the continuous activity at the molecular level is at work.

f) Injection of $COCl_2$ (see c) above).

g) Addition of catalyst will not alter equilibrium concentrations but will increase the rate at which equilibrium recovers from a stress. Any shifts in concentration would become more abrupt.

h) Decrease temperature and increase pressure

i) Temperature will alter K_{eq} values. Hence if there is a change in K_{eq} values, temperature must have been changed