Long Quiz 2 | Chem 132 | March 1, 2013

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Name: Key SB#: 007

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1. With a suitable catalyst, carbon monoxide (CO) and hydrogen ($H_2$) are transformed into methanol ($CH_3OH$) according to the following balanced equation for which $K_c = 14.5$ at 483 K.

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

For a reaction with $[CO]_{initial} = 0.75$ M and $[H_2]_{initial} = 1.25$ M, answer these questions about the attainment of equilibrium:

a. Write the equilibrium constant expression.

$$K_c = \frac{[CH_3OH]}{[CO][H_2]^2}$$

b. Write an "ICE-box" setup for the problem. Use the template given below and confine your answers to the boxes. Use $x$ as your variable in the problem; one box has been filled in to get you started.

| | $CO(g)$ | + | $2\,H_2(g)$ | $\rightleftharpoons$ | $CH_3OH(g)$ |
|---|---|---|---|---|---|
| I | 0.75 | | 1.25 | | — |
| + C | $-x$ | | $-2x$ | | $+x$ |
| E | $0.75-x$ | | $1.25-2x$ | | $x$ |

c. Write the equation to solve to find the value for the variable $x$. ***To conserve time, do NOT solve it.***

$$K_c = 14.5 = \frac{x}{(0.75-x)(1.25-2x)^2}$$

you would solve this

1.25
−0.92
0.33

0.75
−0.46
0.29

d. When the problem is solved, we find $x = 0.46$. What are the equilibrium concentrations of the three compounds in the reaction?

| $[CO]_{eqm}$ = 0.29 M | $[H_2]_{eqm}$ = 0.33 M | $[CH_3OH]_{eqm}$ = 0.46 M |
|---|---|---|

2. For the following reaction, at equilibrium, circle the best response in each row of the table below to say how the reaction will respond to reestablish equilibrium. This reaction is endothermic.

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heat + $2\ POCl_3(g) \rightleftharpoons 2\ PCl_3(g) + O_2(g)$

| Action | Result (circle one per row) | | |
|---|---|---|---|
| add oxygen gas | shift toward reactants | no change | shift toward products |
| remove phosphorus trichloride | shift toward reactants | no change | shift toward products |
| raise temperature to 1000 K from 500 K | shift toward reactants | no change | shift toward products |
| add a catalyst for the reaction | shift toward reactants | no change | shift toward products |
| decrease the volume of the container by half | shift toward reactants | no change | shift toward products |

3. Diamond and graphite are two crystalline forms of carbon. At 1.0 atm and 25 °C, diamond changes to graphite so slowly that the enthalpy change of the process must be obtained indirectly. Determine $\Delta H°_{rxn}$ for the reaction.

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$$C_{(diamond)} \rightleftharpoons C_{(graphite)}$$

You will need ***SOME*** of the following reactions:

use this one → $C_{(diamond)} + O_{2\,(g)} \rightleftharpoons CO_{2(g)}$ $\Delta H° = -395.4$ kJ/mol

$2\ CO_{2(g)} \rightleftharpoons 2\ CO_{(g)} + O_{2(g)}$ $\Delta H° = +566.0$ kJ/mol

use the reverse of this one → $C_{(graphite)} + O_{2(g)} \rightleftharpoons CO_{2(g)}$ $\Delta H° = -393.5$ kJ/mol

$2\ CO_{(g)} \rightleftharpoons C_{(graphite)} + CO_{2(g)}$ $\Delta H° = -172.5$ kJ/mol

395.4
− 393.5
1.9

$CO_{2(g)} \longrightarrow C_{(gr)} + O_2$ $\Delta H° = +393.5$

$C_{(d)} + O_2 \longrightarrow CO_{2(g)}$ $\Delta H° = -395.4$

$C_{(d)} \longrightarrow C_{(gr)}$ $\Delta H° = ?$

$\Delta H° = -1.9$ kJ/mol

4. For each of the following reactions, predict whether the entropy change for the system is positive or negative. Give a ***brief*** explanation for each answer.

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(a) $N_2(g) + 3\ Cl_2(g) \rightarrow 2\ NCl_3(l)$

$\Delta S = \ominus$ b/c gases become liquids means more order, less random

(b) $PCl_5(g) \rightarrow PCl_3(g) + Cl_2(g)$

$\Delta S = \oplus$ b/c one gas becomes two gives a more random system

(c) $CaO(s) + H_2O(l) \rightarrow Ca(OH)_2(s)$

$\Delta S = \ominus$ b/c two things becoming one and the result is more ordered

5. Write the products of this acid-base reaction:

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$HCN(aq) + NH_3(aq) \rightleftharpoons$ $NH_4^+(aq) + CN^-(aq)$

6. Mark this equation to show the conjugate acid-conjugate base pairs.

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