CHM2046 Exam 1 Summer 2020

A 1) a) $3O + 2H_2S_{(g)} + O_{2(g)} \rightleftarrows 2S_{(s)} + 2H_2O_{(g)}$ (ΔH)
- ↑ temp yields ↑ products b/c endothermic
- ↑ volume yields ↓ products b/c 3mol(g) → 2mol(g)
- ↓ O_2 yields ↓ products b/c lowering amount of reactants

b) Le Chatelier's

B 2) I. rate = $K[A]^2[B]$ ✗
II. rate = $K[A][B]$ ✓
III. rate = $K[A][A][B] \rightarrow K[A]^2[B]$ ✗

3) $2A_{(s)} + 2B_{(g)} \rightarrow 2C_{(g)} + 4D_{(g)}$ $K_p = (1\times10^{-2})^2$
$2D_{(g)} \rightarrow E_{(g)} + F_{(g)}$ $K_p = 1\times10^{1}$
$2A_{(s)} + 2B_{(g)} \rightarrow 2C_{(g)} + 2D_{(g)} + E_{(g)} + F_{(g)}$ $K_p = (1\times10^{-2})^2 \cdot (1\times10^{1})$
$\boxed{K_p = 1\times10^{-3}}$

B 4) $A_{(s)} + B_{(g)} \rightarrow C_{(g)} + 2D_{(g)}$ $K_p = 1\times10^{-2}$

	10atm →	∅	∅
	−x →	+x	+2x
	10−x →	x	2x

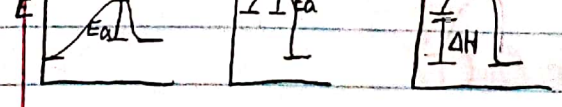
$1\times10^{-2} = \frac{(2x)^2(x)}{(10-x)}$

$.1 = 4x^3$

$x = 0.29\,atm$

$\boxed{2x = 0.58\,atm}$

C 5) A) true, ↑ temp = ↑ collisions
B) true, temp is only thing that changes K
C) false, see below
d) true, less E_a means rxn can go faster



} explanation for c

★ should be ΔH instead of E_a for c ★

A 6) $N_2O_4 \rightleftharpoons 2NO_2$ $K_p = 2$

$y \rightleftharpoons \emptyset$

$-x \rightleftharpoons +2x$

$y-x \rightleftharpoons .2$

$2x = .2$

$x = .1$

$2 = \frac{(.2)^2}{(y-.1)}$

$\boxed{y = 0.12}$

A 7) rxn 1: ↑V, ↓P, shift to more mol (g), (left) X
rxn 2: ↑V, ↓P, shift to more mol (g), (no shift) X

C 8) rxn 1: ↑T, shift left b/c exothermic
rxn 2: ↑T, shift right b/c endothermic

9) $PCl_{5(g)} \rightleftharpoons PCl_{3(g)} + Cl_{2(g)}$ $K_c = 1.05$

$\emptyset \rightleftharpoons 3M + 4M$

$+x \rightleftharpoons -x \quad -x$

$x \rightleftharpoons 3-x \quad 4-x$

$\frac{(3-x)(4-x)}{x} = 1.05$

$12 - 7x + x^2 = 1.05x$

$x^2 - 8.05x + 12 = \emptyset$

$x = 1.98$ V ~~$x = 6.075$~~ reject

$PCl_3 = 3 - 1.98 = \boxed{1.02M}$

E 10) $t_{\frac{1}{2}} = 15$ hrs $\quad t_{\frac{1}{2}} = \frac{\ln 2}{k} = 15 \quad k = 0.046\ hr^{-1}$

$\ln[A]_t = -kt + \ln[A]_0$

$\ln[A]_t = -(.046)(3.24\frac{hrs}{day}) + \ln(1)$

$e^{-3.312} = [A]_t = 0.036$ left

$\approx .96$ decomposed → $\boxed{96\%}$

11) $\frac{1}{8}S_{8(s)} + 3F_{2(g)} \rightleftharpoons SF_{6(g)}$ $K_c = 0.425$

2M 2M ⇌ 2M

$Q = \frac{2}{(2)^3(2)^8} = 0.23$

K > Q, shifts right

E 12) I. rate = $K[NO_2][H_2] \Rightarrow K[NO]^2[H_2]$ X

II. H_2 is twice that of N_2 based on coefficients X

III. rate ≠ H_2 b/c rate is based on H_2 and NO

13) $\frac{\text{rate 2}}{\text{rate 1}} = \frac{K[A]_2^m[B]_2^n}{K[A]_1^m[B]_1^n}$ $\frac{45}{5} = \left(\frac{.3}{.1}\right)^m \rightarrow 9 = 3^m$ $m = 2$

$\frac{\text{rate 4}}{\text{rate 2}} = \frac{K[A]_4^m[B]_4^n}{K[A]_2^m[B]_2^n}$ $\frac{90}{45} = \left(\frac{.2}{.1}\right)^n \rightarrow 2 = 2^n$ $n = 1$

rate = $K[A]^2[B]^1$

$K = \frac{\text{rate}}{[A]^2[B]} = \frac{5}{(.1)^2(.1)} =$ **5000 $M^{-2} \cdot min^{-1}$**

14) $\ln\left(\frac{K_2}{K_1}\right) = \frac{E_a}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$

$\ln\left(\frac{K_2}{4.7 \times 10^{-3}}\right) = \frac{33.6 \times 10^3 \text{ J/mol}}{8.314 \text{ J/mol} \cdot K}\left(\frac{1}{298} - \frac{1}{348}\right)$

$e^{1.949} = \frac{K_2}{4.7 \times 10^{-3}}$

$K_2 = 3.29 \times 10^{-2}$

15) rate = $K[NO][NOBr_2]$ intermediate

$= K[NO][NO][Br_2] = K[NO]^2[Br_2]$

yes, valid mechanism

16) a) 2 steps for the 2 hills
b) 2nd step b/c higher E_a
c) exothermic b/c products have lower energy than reactants

17) $K_b \cdot K_a = K_w$

$$K_b = \frac{K_w}{K_a} = \frac{1 \times 10^{14}}{7.1 \times 10^{-4}} = \boxed{1.41 \times 10^{-11} = K_b}$$