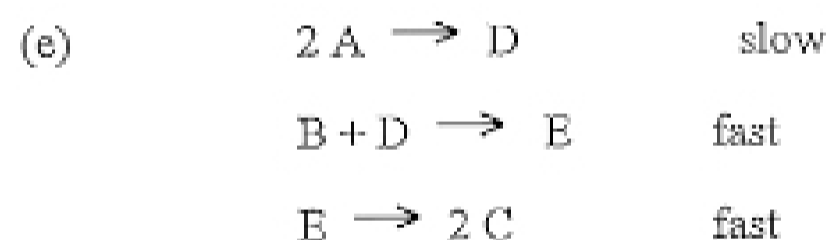
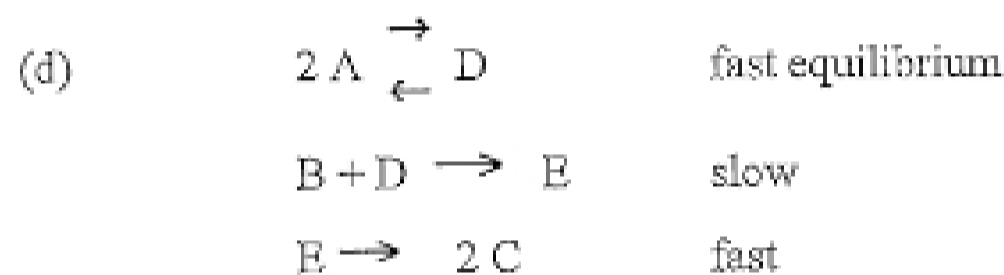
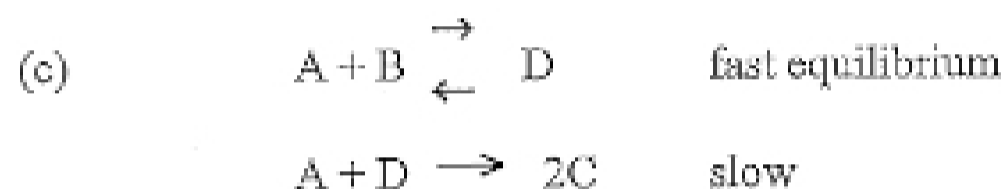
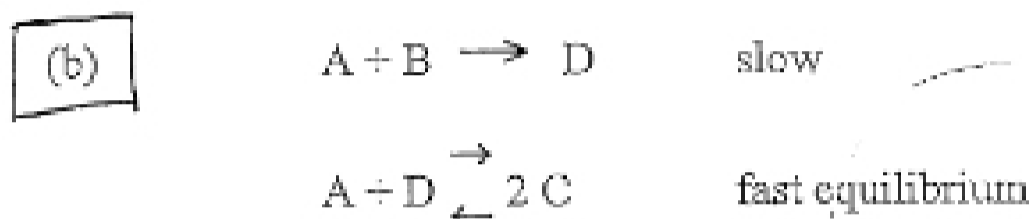
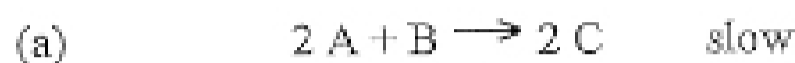
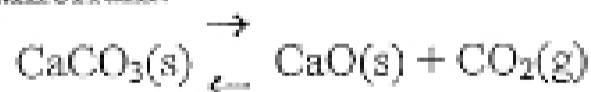


1. The rate law for reaction $2A + B \rightarrow 2C$ is experimentally determined to be first-order in $[A]$ and first-order in B . Which of the following is consistent with the observed rate law?



2. Limestone decomposes at high temperature to form lime and carbon dioxide according to the equilibrium:



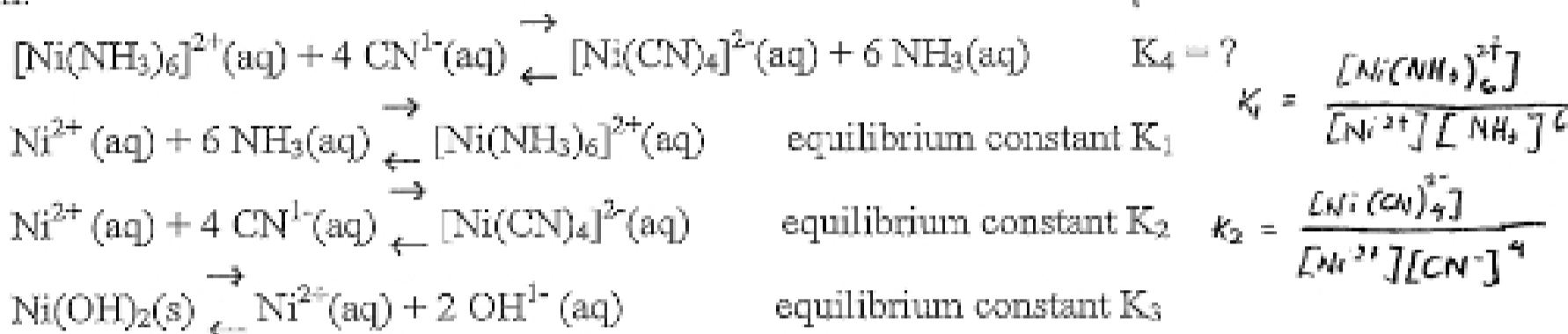
$\Delta H^\circ = +179 \text{ kJ/mol}$ and $\Delta S^\circ = +161 \text{ J/K-mol}$ for this reaction. What is ΔG° and the equilibrium CO_2 pressure above a mixture of $0.5 \text{ mol CaCO}_3(\text{s})$ and $0.1 \text{ mol CaO}(\text{s})$ at 1150 K ?

ΔG° (kJ/mol)	P_{CO_2} (atm)	$\Delta G = \Delta H - T\Delta S$	$\Delta G = -RT \ln K$
(a) -131	2.5×10^8	$\Delta G^\circ = (+179000 \text{ J/mol}) - (1150 \text{ K} \times 161 \text{ J/K-mol})$ $= -6150 \text{ J/mol} \approx \boxed{-6.15 \text{ kJ/mol}}$	$\Delta G = -RT \ln K \rightarrow K = P_{\text{CO}_2} = e^{\left(\frac{\Delta G}{-RT}\right)}$ $K = e^{\left(\frac{-6150 \text{ J/mol}}{-(8.314 \text{ J/mol K}) 1150 \text{ K}}\right)}$ $\boxed{K = 1.9}$
(b) -185	2.5×10^8		
(c) -6.15	4.4		

- (d) -185 2.2x10¹⁹
 (e) -6.15 1.9

$$K_4 = \frac{[\text{Ni}(\text{CN})_4]^{2-} [\text{NH}_3]^6}{[\text{Ni}(\text{NH}_3)_6]^{2+} [\text{CN}^-]^4}$$

3. From the data below, what is the correct expression for the equilibrium constant K₄ for the reaction:



- (a) K₄ = (K₁)(K₂)(K₃) (b) K₄ = (K₁)(K₂) (c) K₄ = (K₂)/(K₁)
 (d) K₄ = K₂ - K₁ (e) K₄ = (K₂ - K₁)/K₃

4. What is the pH of a 0.275 M NH₄Cl(aq) solution? K_a for NH₃(aq) is 1.8x10⁻⁵.

- (a) 1.2x10⁻⁵ (b) 4.92 (c) 7.00 (d) 9.08 (e) 2.65

$$\text{NH}_4^+ \rightleftharpoons \text{NH}_3 + \text{H}^+$$

$$K_a = \frac{[\text{NH}_3][\text{H}^+]}{[\text{NH}_4^+]}$$

$$K_a = \frac{(0.275-x)x}{0.275}$$

$$K_a = \frac{K_w}{K_b} = 5.56 \times 10^{-10}$$

$$[\text{H}^+] = x = 1.29 \times 10^{-5} \text{ M}$$

5. The vapor pressure of pure water at 25°C is 23.8 torr. What is the vapor pressure (in torr) of water above a solution of 18 g of glucose (nonelectrolyte, MW 180 g/mol) in 95 g of water (MW 18 g/mol)?

- (a) 24.3 (b) 23.4 (c) 0.451 (d) 0.443 (e) 23.8

$$\text{mole glucose} = \frac{18\text{g}}{180\text{g/mol}} = 0.1 \quad \text{mole H}_2\text{O} = \frac{95\text{g}}{18\text{g/mol}} = 5.27$$

$$X_{\text{H}_2\text{O}} = \frac{5.27 \text{ mol}}{0.1 \text{ mol} + 5.27 \text{ mol}} = 0.98$$

$$P = X_{\text{H}_2\text{O}} P^\circ = 0.98 \times 23.8 \text{ torr} = 23.4 \text{ torr}$$

6. Acetic acid, HC₂H₃O₂, has a pK_a of 4.74. If one has 1.00 L of a 0.100 M solution of acetic acid, how many moles of solid NaOH would be added to give a pH of 4.90?

- (a) 0.059 (b) 0.100 (c) 0.144 (d) 0.050 (e) 0.041

$$\text{pH} = \text{pK}_a + \log\left(\frac{[\text{base}]}{[\text{acid}]}\right)$$

$$\left[\frac{[\text{base}]}{[\text{acid}]}\right] = 10^{(\text{pH} - \text{pK}_a)}$$

$$\left[\frac{[\text{base}]}{[\text{acid}]}\right] = 1.44$$

$$\left[\frac{[\text{base}]}{[\text{acid}]}\right] = \left(\frac{x}{0.1-x}\right) = 1.44$$

$$x = 0.059$$

7. Consider the Haber process for ammonia:



The reaction is catalyzed by iron metal. Which of the following could a chemical engineer recommend to management to increase the equilibrium amount of ammonia?

- (i) increase the size of the reaction vessel (decrease in P)
 (ii) increase the temperature of the process.
 (iii) increase the amount of iron catalyst.
 ↳ (catalyst, doesn't affect K_{eq})

$$-\Delta H, -\Delta S^\circ$$

$$-\Delta G \text{ at low } T \text{ only!}$$

$$(K_{eq} \uparrow, \text{ higher } [\text{NH}_3]_{\text{eq}})$$

(iv) increase the nitrogen and hydrogen pressure (favors $[NH_3]$ side) ✓✓✓

- (a) i (b) iv (c) iii (d) ii (e) ii and iv

8. For a reaction of $A \rightarrow B + C$ it takes 100 seconds for the concentration of A to decrease from 0.100 M to 0.050 M and then another 200 seconds to decrease to 0.025 M. What is the value of the rate constant?

$rate = k[A]^x$
 $x=2$
 2nd order

- (a) $6.93 \times 10^{-3} s^{-1}$ (b) $0.100 M^{-1} \cdot s^{-1}$ (c) $3.46 \times 10^{-3} s^{-1}$
 (d) $10.0 M^{-1} \cdot s^{-1}$ (e) $144 s^{-1}$

$$\frac{1}{[A]_t} = kt + \frac{1}{[A]_0} \quad k = \left(\frac{\frac{1}{[A]_t} - \frac{1}{[A]_0}}{t} \right)$$

$k = 0.1 M^{-1} s^{-1}$ $k_1 = 1$

9. The activation energy of a reaction whose rate constant increases by a factor of 10.0 when the temperature increases from 303 K to 333 K is _

- (a) 30 kJ/mol (b) 33 kJ/mol (c) 46 kJ/mol (d) 64 kJ/mol (e) 89 kJ/mol

$$\ln\left(\frac{k_1}{k_2}\right) = \frac{E_a}{R} \left(\frac{T_1 - T_2}{T_1 T_2} \right)$$

$k_1 = 1$
 $k_2 = 10$
 $T_1 = 303K$
 $T_2 = 333K$
 solve for E_a !

$E_a = 64385 J/mol$

10. The rate constant for a second-order reaction is $0.47 M^{-1} \cdot s^{-1}$. If the initial concentration of the reactant is 0.25 M, how many seconds will it take for the concentration to decrease to 0.13 M?

- (a) 7.9 (b) 1.4 (c) 3.7 (d) 1.7 (e) 0.13

$$\frac{1}{[A]_t} = kt + \frac{1}{[A]_0}$$

$$t = \left(\frac{\frac{1}{[A]_t} - \frac{1}{[A]_0}}{k} \right) = 7.86 \text{ sec}$$

11. The solubility of oxygen gas in water at 25°C and 1.0 atm of oxygen is 0.041 g/L. What is the solubility of oxygen gas at 3.0 atm and 25°C?

- (a) 0.041 g/L (b) 0.014 g/L (c) 0.31 g/L (d) 0.12 g/L (e) 3.0 g/L

$$C = k P_{gas}$$

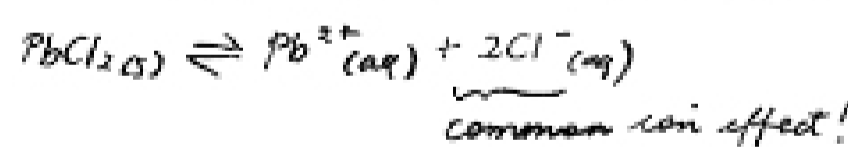
$$C = \left(\frac{0.041 \text{ g/L}}{1 \text{ atm}} \right) \times 3 \text{ atm}$$

$C = 0.123 \text{ g/L}$

12. $PbCl_2$ dissolves as $PbCl_2(s) \rightarrow Pb^{2+}(aq) + 2Cl^{-}(aq)$ with a solubility of 0.016 M at 298 K. What is the molar solubility of $PbCl_2$ in 0.10 M $NaCl(aq)$ solution?

- (a) 0.12 M (b) $4.1 \times 10^{-5} M$ (c) $1.6 \times 10^{-3} M$
 (d) $5.1 \times 10^{-3} M$ (e) $1.6 \times 10^{-5} M$

$$\frac{K_{sp}}{[Cl^{-}]} = \frac{0.016}{0.10} = 1.6 \times 10^{-3} M$$



13. In the balanced chemical equation,



which takes place in acidic aqueous solution, the ratio of coefficients b/a to 3 significant figures is

- (a) 2.50 (b) 1.60 (c) 2.00 (d) 8.00 (e) 3.20

$a = 5$
 $b = 16$ $f = 4$
 $c = 1$
 $d = 1$
 $e = 1$

14. Based upon the standard reduction potentials below, which of the following statements are correct?