

Equations:

For the reaction: $aA + bB \rightleftharpoons cC + dD$

1st order reactions:

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

$$t_{1/2} = \frac{0.693}{k}$$

$$\text{Rate} = -\frac{1}{a} \frac{\Delta[A]}{\Delta t} = -\frac{1}{b} \frac{\Delta[B]}{\Delta t} = +\frac{1}{c} \frac{\Delta[C]}{\Delta t} = +\frac{1}{d} \frac{\Delta[D]}{\Delta t}$$

$$K_c = \frac{[C]^c [D]^d}{[A]^a [B]^b}$$

2nd order reactions:

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

$$t_{1/2} = \frac{1}{k[A]_0}$$

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

$$\Delta S^\circ = \sum nS^\circ(\text{products}) - \sum mS^\circ(\text{reactants})$$

Arrhenius:

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

$$\ln k = -(E_a/RT) + \ln A$$

$$\Delta G^\circ = \sum nG_f^\circ(\text{products}) - \sum mG_f^\circ(\text{reactants})$$

$$\ln (k_1/k_2) = E_a/R (1/T_2 - 1/T_1)$$

$$\Delta G = \Delta G^\circ + RT \ln Q \quad (R = 8.314 \text{ J/mol}\cdot\text{K})$$

$$R = 8.314 \text{ J/mol}\cdot\text{K}$$

$$\Delta G^\circ = -RT \ln K \quad (R = 8.314 \text{ J/mol}\cdot\text{K})$$

$$K_p = K_c (RT)^{\Delta n}$$

$$E^\circ_{\text{cell}} = E^\circ_{\text{red}}(\text{cathode}) - E^\circ_{\text{red}}(\text{anode})$$

$$(R = 0.0821 \text{ L}\cdot\text{atm/mol}\cdot\text{K})$$

$$\Delta G = -nFE \quad (F = 96,500 \text{ J/V}\cdot\text{mol})$$

$$K_w = 1.0 \times 10^{-14}; \text{pH} = -\log[\text{H}^+]$$

$$E = E^\circ - \frac{0.0592 \text{ V}}{n} \log Q \quad (T = 298 \text{ K})$$

$$\log K = \frac{nE^\circ}{0.0592} \quad (T = 298 \text{ K})$$

$$E = mc^2 \quad (c = 3.0 \times 10^8 \text{ m/s})$$

$$1 \text{ J} = 1 \frac{\text{kg}\cdot\text{m}^2}{\text{s}^2}$$

charge of 1 mol of electrons = 96,500 C = 1 Faraday

Coulombs = amperes x seconds

New Material:

1. The electron configuration of V^{3+} is

- (a) $[Ar]4s^23d^3$
(b) $[Ar]4s^23d^5$
 (c) $[Ar]3d^2$
(d) $[Ar]4s$

2. The lanthanide contraction is responsible for the fact that _____.

- (a) Zr and Y have about the same atomic radius
(b) Zr and Nb have similar oxidation states
(c) Zr and Zn have similar oxidation states
 (d) Zr and Hf have about the same radius

3. Which one of the following species is paramagnetic?

- (a) Zn^{2+}
(b) Ti^{3+}
 (c) Mn^{5+}
(d) V^{3+}

4. In _____ the bonds are the same, but the spatial arrangement of the atoms is different.

- (a) structural isomers
(b) linkage isomers
(c) coordination sphere isomers
 (d) stereoisomers

5. Hydrocarbons containing carbon-carbon triple bonds are called _____.

- (a) alkynes
(b) alkenes
(c) alkanes
(d) olefins

6. Metals typically have _____.

- (a) low electronegativities and high first ionization energies
 (b) low electronegativities and low first ionization energies
(c) high electronegativities and high first ionization energies
(d) high electronegativities and high electron affinities

7. What is the coordination number of chromium in $[\text{Cr}(\text{H}_2\text{O})_4\text{Cl}_2]^-$?

d

- (a) 8
- (b) 2
- (c) 4
- (d) 6

8. The general formula for an ether is _____.

c

- (a) R-CO-OH
- (b) R-CO-R'
- (c) R-O-R'
- (d) R-CO-H

9. A ligand with a single donor atom is called _____.

a

- (a) monodentate
- (b) bidentate
- (c) a chelate
- (d) polydentate

10. How many ligands are there in the coordination sphere of $[\text{Co}(\text{en})_2\text{Cl}_2]^+$?

d

- (a) 3
- (b) 6
- (c) 1
- (d) 4

11. Alkenes have the general formula _____.

a

- (a) C_nH_{2n}
- (b) $\text{C}_n\text{H}_{2n-2}$
- (c) $\text{C}_n\text{H}_{2n+2}$
- (d) C_{2n}H_n

12. During the formation of a coordination compound, the metal acts as a _____.

c

- (a) Lewis base
- (b) Arrhenius acid
- (c) Lewis acid
- (d) Bronsted Acid

13. A substance with unpaired electrons will be _____.

d

- (a) permanently magnetic
- (b) nonmetallic
- (c) slightly repelled by a magnet
- (d) slightly attracted to a magnet

14. What is the ligand in $\text{Ca}_3[\text{Fe}(\text{CN})_6]_2$?

c

- (a) Ca^{2+}
- (b) Fe^{3+}
- (c) CN^-
- (d) N^3

15. $\text{CH}_3\text{CH}_2\text{C}(=\text{O})\text{NH}_2$ is called a(n) _____.

c

- (a) amine
- (b) aldehyde
- (c) amide
- (d) ketone

16. Optically active molecules that are mirror images of each other are called _____.

a

- (a) enantiomers
- (b) allotropes
- (c) chiral compounds
- (d) geometrical isomers

17. Which one of the following species is a potential polydentate ligand (chelating agent)?

d

- (a) NH_3
- (b) Cl^-
- (c) CN^-
- (d) $\text{C}_2\text{O}_4^{2-}$

18. Proteins are biopolymers formed via multiple condensation coupling of which two functional groups?

b

- (a) ester and amine
- (b) amine and carboxylic acid
- (c) alcohol and carboxylic acid
- (d) alcohol and amine

19. Complexes containing metals with which one of the following electron configurations are usually colorless?

d

- (a) d^2
- (b) d^1
- (c) d^8
- (d) d^{10}

20. Which geometry does not exhibit cis/trans isomerism?

c

- (a) octahedral
- (b) square planar
- (c) tetrahedral
- (d) all geometries can exhibit cis/trans isomerism

21. Which substance would be the most soluble in gasoline?

d

- (a) water
- (b) NaNO_3
- (c) HCl
- (d) hexane

22. Which one of the following is NOT true about transition metals?

c

- (a) They frequently have more than one common oxidation state.
- (b) Their compounds are frequently colored.
- (c) They typically cannot have unpaired electrons.
- (d) They are found in the d-block of the periodic table.

23. Carboxylic acids can be formed by oxidation of _____.

a

- (a) alcohols
- (b) alkynes
- (c) alkenes
- (d) ketones

24. The correct name for $[\text{Ni}(\text{NH}_3)_6](\text{NO}_3)_3$ is:

c

- (a) dinitrohexaamminenickel(II)
- (b) hexaamminenickel(III) trinitrate
- (c) hexaamminenickel(II) nitrate
- (d) hexaamminenickel(II) nitrate

25. How many isomers are possible for C_4H_{10} ?

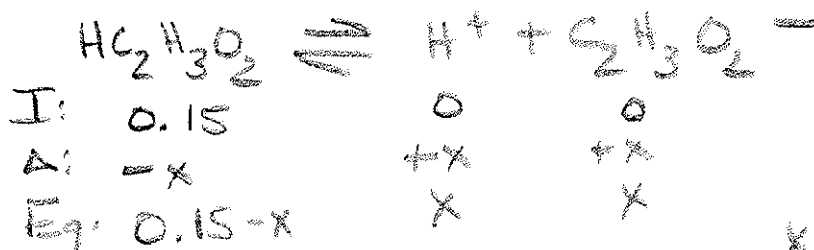
- a
- (a) 2 ① $CH_3CH_2CH_2CH_3$
 (b) 1
 (c) 3 ② $CH_3-\underset{\substack{| \\ CH_3}}{CH}-CH_2CH_3$
 (d) 4

Comprehensive Review Material:

H

26. The pH of a 0.15 M aqueous solution of $HC_2H_3O_2$ (acetic acid) at 25 °C is _____.
 The K_a for $HC_2H_3O_2$ is 1.8×10^{-5} .

- a
- (a) 2.78
 (b) 9.18
 (c) 7.35
 (f) 5.57



27. The reaction



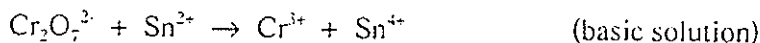
$$1.8 \times 10^{-5} = \frac{x^2}{0.15 - x}$$

has $K_c = 0.89$ at 672 K. At equilibrium, _____.

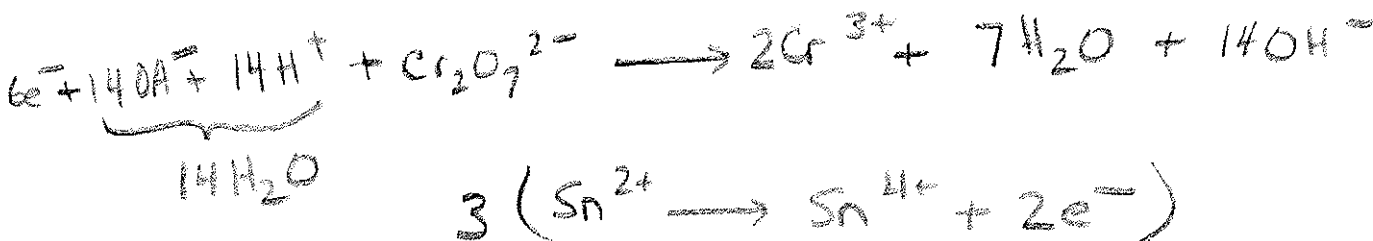
$$x = [H^+] = 1.64 \times 10^{-3}$$

- c
- (a) products predominate substantially
 (b) reactants predominate substantially
 (c) roughly equal amounts of products and reactants are present
 (d) only reactants are present

28. What is the coefficient of $Cr_2O_7^{2-}$ when the following reaction is correctly balanced?



- d
- (a) 2
 (b) 3
 (c) 4
 (d) 1



29. The equilibrium expression K_c for the following reaction is _____.



(a) $\frac{[\text{CO}_2]^6}{[\text{O}_2]^6}$

(b) $\frac{[\text{C}_6\text{H}_{12}\text{O}_6][\text{O}_2]^6}{[\text{CO}_2]^6[\text{H}_2\text{O}]^6}$

(c) $\frac{[\text{O}_2]^6}{[\text{CO}_2]^6}$

(d) $[\text{O}_2]^6$

$$K_c = \frac{[\text{O}_2]^6}{[\text{CO}_2]^6}$$

30. The kinetics of the reaction below were studied and it was determined that the reaction rate decreased by a factor of 9 when the concentration of B was tripled. The reaction is _____ order in B.



Exp	[B]	Rate
1	1.0M	1.0×10^{-3}
2	3.0M	1.1×10^{-4}

$$\text{Rate} = ([\text{B}]^x)$$

$$\frac{1.0 \times 10^{-3}}{1.1 \times 10^{-4}} = \left(\frac{1}{3}\right)^x$$

$$9.00 = \left(\frac{1}{3}\right)^x$$

$$\log 9.00 = \left(\log \frac{1}{3}\right) x$$

$$0.95 = (-0.48) x$$

$$x = -2$$

Throw this one out

- (a) one-third
 (b) one-half
 (c) first
 (d) second

31. Which type of radioactive decay results in no change in mass number and atomic number for the starting nucleus?

- (a) alpha
 (b) beta
 (c) gamma
 (d) electron capture

32. The equilibrium constant for a reaction is 0.48 at 25 °C. What is the value of ΔG° (in kJ) at this temperature?

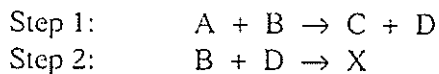
- (a) 1.8
 (b) -4.2
 (c) 4.2
 (d) 150

$$\Delta G = -RT \ln K$$

$$\Delta G = -(8.314 \text{ J/mol}\cdot\text{K})(298 \text{ K}) \ln(0.48)$$

$$\Delta G = +1.8 \text{ kJ}$$

33. The mechanism for formation of product X is:



The intermediate in this reaction is _____.

- (a) A
(b) B
(c) C
 (d) D

d

34. Which species from the following list would be the strongest Bronsted-Lowry base?

- (a) ClO_3^-
(b) NO_3^-
 (c) CN^-
(d) Cl^-

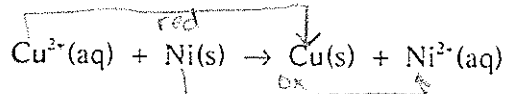
c

35. Given the following information

Half-reaction	E°_{red}
$\text{Cu}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Cu}(\text{s})$	+0.337 V
$\text{Ni}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Ni}(\text{s})$	-0.280 V

$$\begin{aligned} E^\circ_{\text{cell}} &= E^\circ_{\text{cathode}} - E^\circ_{\text{anode}} \\ &= 0.337\text{V} - (-0.280\text{V}) \\ &= 0.617\text{V} \end{aligned}$$

Consider an electrochemical cell based on the reaction



Determine the cell potential (in V) when the concentration of Ni^{2+} is 0.155 M and the concentration of Cu^{2+} is 0.352 M ($T = 298\text{ K}$).

- (a) 0.617
 (b) 0.628
(c) 0.600
(d) 0.606

$$E = E^\circ - \frac{0.0592\text{V}}{n} \log Q$$

$$= 0.617\text{V} - \frac{0.0592\text{V}}{2} \log \frac{0.155}{0.352}$$

b

36. Isotopes of hydrogen

- (a) have the same atomic number and different mass numbers
(b) have the same atomic number and the same mass number
(c) are exactly alike
(d) have different atomic numbers and the same mass number

a

37. A _____ yields a titration curve with an initial pH of 1.00, an equivalence point at pH = 7.0, and a relatively long, nearly vertical middle section.

b

- (a) weak acid titrated by a weak base
- (b) strong acid titrated by a strong base
- (c) weak base titrated by a strong acid
- (d) strong base titrated by a strong acid

38. Consider the following table of thermodynamic data.

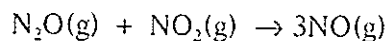
Substance	ΔG_f° (kJ/mol)	S° (J/mol·K)
NO(g)	86.7	211
NO ₂ (g)	51.8	240
NOCl	66.3	264
N ₂ O	103.6	220

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

$$104.7 \times 10^3 \text{ J} = \Delta H - (298 \text{ K})(173)$$

$$\Delta H = 156.3 \text{ kJ}$$

Determine the value of ΔH° (in kJ) for the following reaction taking place at 25 °C.



c

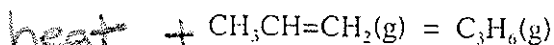
- (a) 109.0
- (b) 53.2
- (c) 156.2
- (d) 52.4

$$\Delta G_f^\circ = [3(86.7 \frac{\text{kJ}}{\text{mol}})] - [103.6 + 51.8]$$

$$= 104.7 \text{ kJ/mol}$$

$$\Delta S^\circ = [3(211 \text{ J/mol}\cdot\text{K})] - [220 + 240] = 173 \text{ J/K}$$

39. Le Chatelier's principle predicts which action below to cause the endothermic reaction



to form more $\text{CH}_3\text{CH}=\text{CH}_2$ than initially present at equilibrium?

c

- (a) increasing the system pressure
- (b) decreasing the system pressure
- (c) decreasing the system temperature
- (d) increasing the system temperature

40. The effect of a catalyst on an equilibrium is to _____.

c

- (a) increase the rate of the forward reaction only
- (b) increase the equilibrium constant so that products are favored
- (c) increase the rate at which equilibrium is achieved without changing the composition of the equilibrium mixture
- (d) slow the reverse reaction only

$$K_a \cdot K_b = K_w$$

$$K_b = \frac{K_w}{0.15x} = 1.6 \times 10^{-6}$$

but, $x = [OH^-] \Rightarrow$ we can derive this from pH:
 $pH = -\log [H^+]$
 $[H^+] = 1.99 \times 10^{-11}$
 $\therefore [OH^-] = 5.03 \times 10^{-4} M$

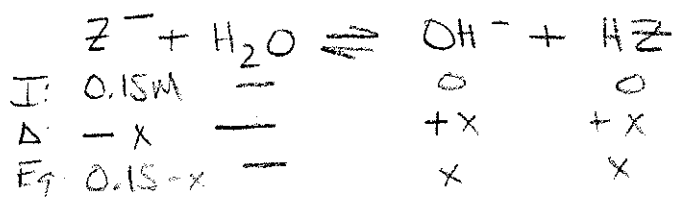
41. In the Arrhenius equation (shown below)

$$\ln k = -(E_a/RT) + \ln A$$

_____ is the frequency factor.

- a
- (a) A
 - (b) k
 - (c) E_a
 - (d) R

42. The pH of a 0.15 M aqueous solution of NaZ (the sodium salt of HZ) is 10.7. What is the K_a value for HZ?

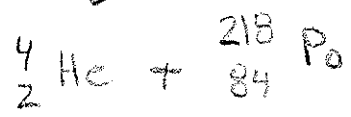
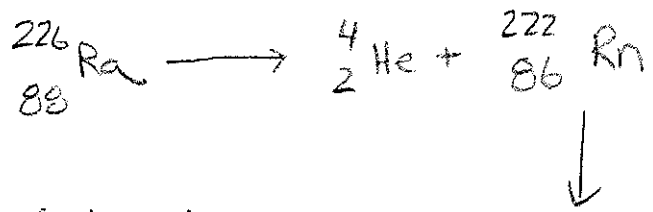


- d
- (a) 3.3×10^{-8}
 - (b) 1.6×10^{-6}
 - (c) 8.9×10^{-4}
 - (d) 6.0×10^{-9}

43. Which of the following transformations could take place at the cathode of an electrochemical cell?

- d
- (a) $MnO_2 \xrightarrow{+4} MnO_4^- \xrightarrow{+7}$
 - (b) $Br_2 \xrightarrow{0} BrO_3^- \xrightarrow{+5}$
 - (c) $NO \xrightarrow{+2} HNO_2 \xrightarrow{+3}$
 - (d) $HSO_4^- \xrightarrow{+6} H_2SO_3 \xrightarrow{+4}$

44. Radium undergoes alpha decay. The product of this reaction also undergoes alpha decay. What is the product of this second decay reaction?

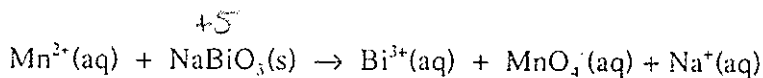


- a
- (a) Po
 - (b) Rn
 - (c) U
 - (d) Th

45. ΔS° will be positive for the reaction

- a
- (a) $BaF_2(s) \rightarrow Ba^{2+}(aq) + 2F^-(aq)$
 - (b) $2NO_2(g) \rightarrow N_2O_4(g)$
 - (c) $2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$
 - (d) $2Hg(l) + O_2(g) \rightarrow 2HgO(s)$

46. Which element is reduced in the reaction below?



- (a) Mn
 (b) Na
 (c) Bi
 (d) O

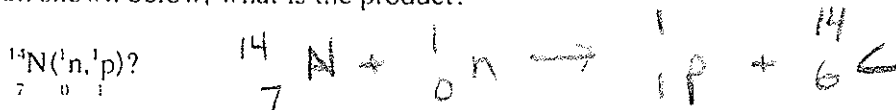
c

47. The more _____ the E° red value for a half-reaction, the greater the tendency for the reactant in the half-reaction to act as an oxidizing agent.

- (a) positive
 (b) negative
 (c) exothermic
 (d) endothermic

a

48. In the nuclear transmutation shown below, what is the product?



- (a) carbon-12
 (b) carbon -16
 (c) carbon-14
 (d) nitrogen-15

c

49. What is the half-life of a second-order reaction with the rate constant $0.0271 \text{ M}^{-1}\text{s}^{-1}$ and the initial reactant concentration of 0.902 M ?

- (a) 40.9 s
 (b) 25.6 s
 (c) 0.451 s
 (d) 0.625 s

$$t_{1/2} = \frac{1}{k[A]_0} = \frac{1}{(0.0271 \text{ M}^{-1}\text{s}^{-1})(0.902)}$$

a

50. Determine the pH of a solution prepared by mixing 45 mL of 0.183 M KOH with 65 mL of 0.145 M HCl .

- (a) 1.31
 (b) 2.92
 (c) 0.74
 (d) 1.97

KOH: $0.183 \frac{\text{mol}}{\text{L}} \times 0.045 \text{ L} = 8.24 \times 10^{-3} \text{ moles}$

HCl: $0.145 \frac{\text{mol}}{\text{L}} \times 0.065 \text{ L} = 9.43 \times 10^{-3} \text{ moles}$

excess acid $\frac{1.19 \times 10^{-3} \text{ mol}}{0.11 \text{ L}}$

$$[\text{H}^+] = 1.08 \times 10^{-2}$$

d