KEY

Chemistry 232 Winter 2015 Oregon State University
Final Exam March 16, 2015 Drs. Nafshun, Sleszynski, Watson, Oscar, Ogba

Instructions: You should have with you several number two pencils, an eraser, your 3" x 5" note card, a calculator, and your University ID Card. If you have notes with you, place them in a sealed backpack and place the backpack OUT OF SIGHT or place the notes directly on the table at the front of the room.

Fill in the front page of the Scantron answer sheet with your class section number (see below), last name, first name, middle initial, and student identification number. Leave the test form number blank.

Section 001 (MWF 8am with Dr. Nafshun)
Section 002 (MWF 9am with Dr. Nafshun)
Section 003 (MWF 10am with Dr. Sleszynski)
Section 004 (MWF 11am with Dr. Watson)
Section 005 (MWF 1pm with Oscar)
Section 006 (MWF 2pm with Ogba)

This exam consists of 32 multiple-choice questions; each has 5 points attached. When you finish this exam, proceed to the proctor. Flash your OSU ID Card and submit your completed Scantron form. You may take your notecard and this exam packet with you.

| Zero-Order | First-Order | Second-Order |
|---|---|---|
| $[A]_t = -kt + [A]_0$ | $\ln [A] = -kt + \ln [A]_0$ | $\frac{1}{[A]} = kt + \frac{1}{[A]_0}$ |
| $k = Ae^{-E_a/(RT)}$ | $\ln(k) = \frac{-E_a}{R}\frac{1}{T} + \ln(A)$ | $\ln \frac{k_2}{k_1} = \frac{E_a}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$ |

| | | |
|---|---|---|
| $R = 8.314 \frac{J}{mol \bullet K}$ | 760 mm Hg = 760 torr = 1 atm | |
| M = mol/L | $\Delta T_f = imk_f$ | $\Delta T_b = imk_b$ |
| m = mol/kg | $k_f (H_2O) = 1.86$ °C/m | $k_b(H_2O) = 0.512$ °C/m |
| | $\Pi V = nRT$ | |
| For SC: $l = 2r$ | For BCC: $l = 4r/\sqrt{3}$ | For FCC: $l = 4r/\sqrt{2}$ |
| 1 m = 1 x $10^{12}$ pm | 1 m = 100 cm | |

# Solubility Rules for Ionic Compounds

**Rule 1: All nitrates, acetates, Group 1A metal salts and ammonium salts are soluble.**
**Rule 2: Carbonates, hydroxides, phosphates and sulfides are nearly always insoluble.**
**Rule 3: Chlorides, bromides and iodides are always soluble except with $Ag^+$ and $Pb^{2+}$.**
**Rule 4: Rule 1 always takes precedence.**

| Substance | FM (g/mol) | MP (°C) | $\Delta H_{(fusion)}$ (J/g) | BP (°C) | $\Delta H_{(vap)}$ (J/g) | Specific Heat (J/g°C)* Solid | Liquid | Gas |
|---|---|---|---|---|---|---|---|---|
| acetone | 58.1 | -95.1 | 96.7 | 56.1 | 520 | 2.26 | 2.20 | 1.46 |
| benzene | 78.1 | 5.41 | 126 | 80.1 | 394 | 1.20 | 1.90 | 1.17 |
| ethanol | 46.1 | -112 | 100 | 78.3 | 852 | 0.96 | 2.10 | 1.71 |
| n-octane | 114 | -57.0 | 182 | 126 | 339 | 1.30 | 2.40 | 1.30 |
| water | 18.0 | 0.00 | 334 | 100 | 2260 | 2.09 | 4.18 | 1.38 |

## The Periodic Table of the Elements

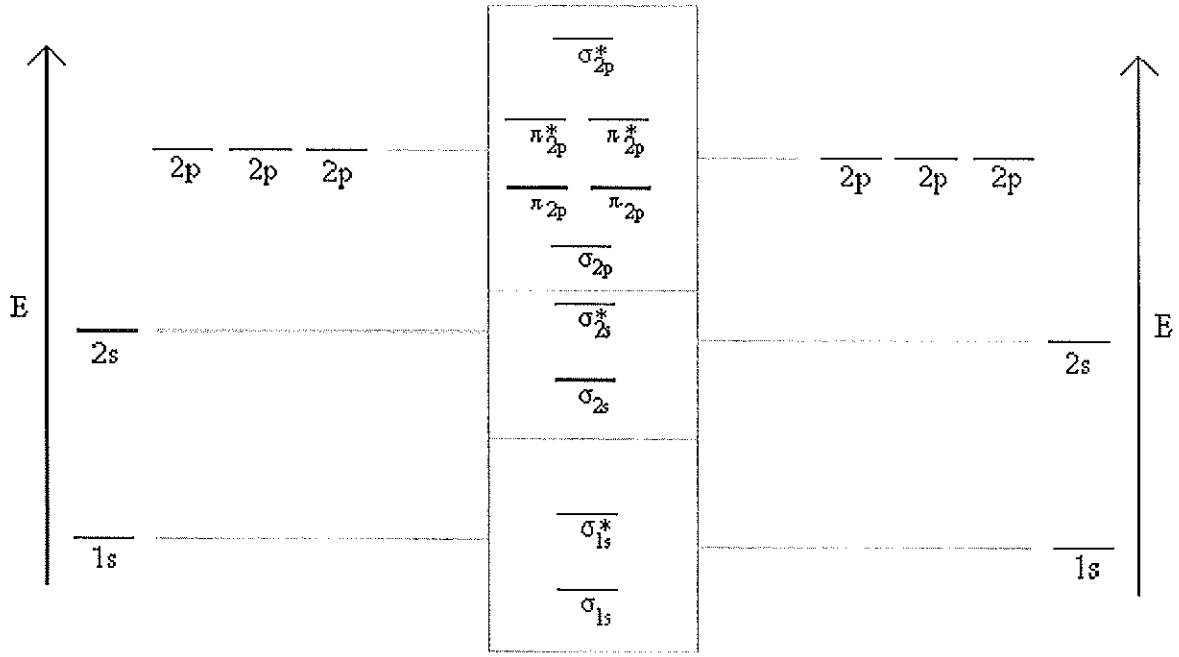
| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 H Hydrogen 1.00794 | | | | | | | | | | | | | | | | | 2 He Helium 4.003 |
| 3 Li Lithium 6.941 | 4 Be Beryllium 9.012182 | | | | | | | | | | | 5 B Boron 10.811 | 6 C Carbon 12.0107 | 7 N Nitrogen 14.00674 | 8 O Oxygen 15.9994 | 9 F Fluorine 18.9984032 | 10 Ne Neon 20.1797 |
| 11 Na Sodium 22.989770 | 12 Mg Magnesium 24.3050 | | | | | | | | | | | 13 Al Aluminum 26.981538 | 14 Si Silicon 28.0855 | 15 P Phosphorus 30.973761 | 16 S Sulfur 32.066 | 17 Cl Chlorine 35.4527 | 18 Ar Argon 39.948 |
| 19 K Potassium 39.0983 | 20 Ca Calcium 40.078 | 21 Sc Scandium 44.955910 | 22 Ti Titanium 47.867 | 23 V Vanadium 50.9415 | 24 Cr Chromium 51.9961 | 25 Mn Manganese 54.938049 | 26 Fe Iron 55.845 | 27 Co Cobalt 58.933200 | 28 Ni Nickel 58.6934 | 29 Cu Copper 63.546 | 30 Zn Zinc 65.39 | 31 Ga Gallium 69.723 | 32 Ge Germanium 72.61 | 33 As Arsenic 74.92160 | 34 Se Selenium 78.96 | 35 Br Bromine 79.904 | 36 Kr Krypton 83.80 |
| 37 Rb Rubidium 85.4678 | 38 Sr Strontium 87.62 | 39 Y Yttrium 88.90585 | 40 Zr Zirconium 91.224 | 41 Nb Niobium 92.90638 | 42 Mo Molybdenum 95.94 | 43 Tc Technetium (98) | 44 Ru Ruthenium 101.07 | 45 Rh Rhodium 102.90550 | 46 Pd Palladium 106.42 | 47 Ag Silver 107.8682 | 48 Cd Cadmium 112.411 | 49 In Indium 114.818 | 50 Sn Tin 118.710 | 51 Sb Antimony 121.760 | 52 Te Tellurium 127.60 | 53 I Iodine 126.90447 | 54 Xe Xenon 131.29 |
| 55 Cs Cesium 132.90545 | 56 Ba Barium 137.327 | 57 La Lanthanum 138.9055 | 72 Hf Hafnium 178.49 | 73 Ta Tantalum 180.9479 | 74 W Tungsten 183.84 | 75 Re Rhenium 186.207 | 76 Os Osmium 190.23 | 77 Ir Iridium 192.217 | 78 Pt Platinum 195.078 | 79 Au Gold 196.96655 | 80 Hg Mercury 200.59 | 81 Tl Thallium 204.3833 | 82 Pb Lead 207.2 | 83 Bi Bismuth 208.98038 | 84 Po Polonium (209) | 85 At Astatine (210) | 86 Rn Radon (222) |
| 87 Fr Francium (223) | 88 Ra Radium (226) | 89 Ac Actinium (227) | 104 Rf Rutherfordium (261) | 105 Db Dubnium (262) | 106 Sg Seaborgium (263) | 107 Bh Bohrium (262) | 108 Hs Hassium (265) | 109 Mt Meitnerium (266) | 110 (269) | 111 (272) | 112 (277) | 113 | 114 | | | | |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 58 Ce Cerium 140.116 | 59 Pr Praseodymium 140.90765 | 60 Nd Neodymium 144.24 | 61 Pm Promethium (145) | 62 Sm Samarium 150.36 | 63 Eu Europium 151.964 | 64 Gd Gadolinium 157.25 | 65 Tb Terbium 158.92534 | 66 Dy Dysprosium 162.50 | 67 Ho Holmium 164.93032 | 68 Er Erbium 167.26 | 69 Tm Thulium 168.93421 | 70 Yb Ytterbium 173.04 | 71 Lu Lutetium 174.967 |
| 90 Th Thorium 232.0381 | 91 Pa Protactinium 231.03588 | 92 U Uranium 238.0289 | 93 Np Neptunium (237) | 94 Pu Plutonium (244) | 95 Am Americium (243) | 96 Cm Curium (247) | 97 Bk Berkelium (247) | 98 Cf Californium (251) | 99 Es Einsteinium (252) | 100 Fm Fermium (257) | 101 Md Mendelevium (258) | 102 No Nobelium (259) | 103 Lr Lawrencium (262) |

| | |
|---|---|
| $K_a[CH_3COOH\ (aq)] = 1.80 \times 10^{-5}$ (acetic acid) | $K_a[C_6H_5COOH\ (aq)] = 6.30 \times 10^{-5}$ (benzoic acid) |
| $K_a[CH_2ClCOOH\ (aq)] = 1.40 \times 10^{-3}$ (chloroacetic acid) | $K_b[NH_3\ (aq)] = 1.80 \times 10^{-5}$ (ammonia) |
| $K_a[HClO\ (aq)] = 2.90 \times 10^{-8}$ (hypochlorous acid) | $K_a[CH_3CH_2CH_2CH_2COOH\ (aq)] = 1.45 \times 10^{-5}$ (pentanoic acid) |
| $K_a[HF\ (aq)] = 6.30 \times 10^{-4}$ (hydrofluoric acid) | $K_b\ [CH_3NH_2] = 3.70 \times 10^{-4}$ (methylamine) |
| $K_a[HCOOH\ (aq)] = 1.80 \times 10^{-4}$ (formic acid) | $K_{sp}\ [Fe(OH)_2] = 4.87 \times 10^{-17}$ |
| $K_{sp}\ [PbF_2] = 3.6 \times 10^{-8}$ | $K_{sp}\ [MgF_2] = 3.7 \times 10^{-8}$ |
| $K_{sp}\ [Cd(OH)_2] = 7.2 \times 10^{-15}$ | $K_{sp}\ [PbI_2] = 1.4 \times 10^{-8}$ |
| $K_{sp}\ [CaSO_4] = 2.4 \times 10^{-5}$ | $K_{sp}\ [CaC_2O_4] = 2.3 \times 10^{-9}$ |
| $K_{sp}\ [CuCl] = 1.0 \times 10^{-6}$ | $K_{sp}\ [AgCl] = 1.77 \times 10^{-10}$ |

# Electron Pair and Molecular Geometries

| Number of Electron Groups | Number of Lone Pairs | Electron Pair Geometry | Molecular Geometry |
|---|---|---|---|
| 2 | 0 | Linear | Linear |
| 3 | 0 | Trigonal planar | Trigonal planar |
| | 1 | Trigonal planar | Bent |
| 4 | 0 | Tetrahedral ($T_d$) | Tetrahedral ($T_d$) |
| | 1 | Tetrahedral ($T_d$) | Trigonal pyramidal |
| | 2 | Tetrahedral ($T_d$) | Bent |
| 5 | 0 | Trigonal bipyramidal | Trigonal bipyramidal |
| | 1 | Trigonal bipyramidal | See-Saw |
| | 2 | Trigonal bipyramidal | T-Shaped |
| | 3 | Trigonal bipyramidal | Linear |
| 6 | 0 | Octahedral ($O_h$) | Octahedral ($O_h$) |
| | 1 | Octahedral ($O_h$) | Square pyramidal |
| | 2 | Octahedral ($O_h$) | Square planar |

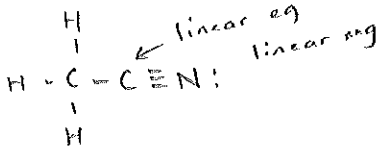



Late 2nd-period $A_2$ Diatomics Scheme

| | | |
|---|---|---|
| PV = nRT | $\frac{P_1V_1}{n_1T_1} = \frac{P_2V_2}{n_2T_2}$ | $\mu_{rms} = \sqrt{\frac{3RT}{Molar\ Mass}}$ |
| $R = 0.08206\ \frac{L \bullet atm}{mol \bullet K}$ | $R = 8.314\ \frac{kg \bullet m^2}{s^2 \bullet mol \bullet K}$ | 760 Torr = 1 atm = 760 mm Hg |
| K = 273.15 + °C | 1 mole = $6.02 \times 10^{23}$ | Ideal Molar volume = 22.414 L @ STP (STP = 1 atm and 273.15 K) |

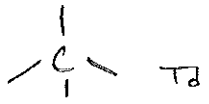
1. Determine the electron geometry (eg) and molecular geometry (mg) of the carbon bonded to the nitrogen in acetonitrile, $CH_3CN$.

(A) eg=tetrahedral mg=tetrahedral
(B) eg=tetrahedral mg=trigonal pyramidal
(C) eg=trigonal planar mg=bent
(D) eg=trigonal planar mg=trigonal planar
(E) eg=linear mg=linear



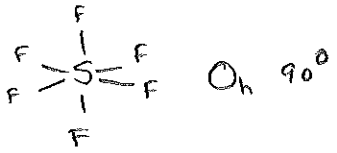

2. What electron arrangement of charge clouds is expected for an atom that has four electron groups (charge clouds)?

(A) trigonal bipyramidal
(B) trigonal pyramidal
(C) trigonal planar
(D) square planar
(E) tetrahedral




3. What are the approximate bond angles about the sulfur in $SF_6$?

(A) 160°
(B) 120°
(C) 109.5°
(D) 90°
(E) 60°



4. Which of the following gases exhibit the ***largest*** average kinetic energy at STP?

(A) $NH_3$
(B) He
(C) $CO_2$
(D) All have the same average kinetic energy
(E) There is not enough information to answer this question.

$KE = \frac{3}{2}kT$ ↖ not mass dependent

Partial Credit: E = 2 pts

5. $N_2O$ gas has a density of 2.85 g/L at 25.0 °C. What is the pressure of the gas?

(A) 0.130 atm
(B) 5.13 atm
(C) 1.58 atm
(D) 1.00 atm
(E) There is not enough information to determine the pressure

$2.85\ g\ N_2O \left(\frac{1\ mol}{44.02\ g}\right) = 0.0647\ mol$ (1 L)

$P = \frac{nRT}{V} = \frac{(0.0647\ mol)(0.08206\ \frac{L \cdot atm}{mol \cdot K})(298\ K)}{1\ L} = 1.58\ atm$

6. Methane ($CH_4$) reacts with water to form hydrogen gas and carbon monoxide. What volume of methane is required to produce 50.0 g of $H_2$ (g) at 298 K and 0.950 atm?

$$CH_4\ (g) + H_2O\ (l) \rightarrow 3\ H_2\ (g) + CO\ (g)$$

50.0 g ↓ (1)

638.5 L ← (2) L

(A) 192 L
(B) 214 L
(C) 1280 L
(D) 638 L
(E) 1920 L

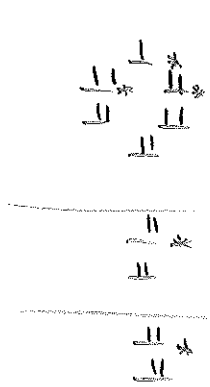
(1) $50.0\ g\ H_2 \left(\frac{1\ mol}{2.0158\ g}\right) = 24.80\ mol\ H_2$

$V = \frac{nRT}{P} = \frac{(24.80\ mol)(0.08206\ \frac{L \cdot atm}{mol \cdot K})(298\ K)}{(0.950\ atm)} = 638.5\ L$

(2) $638.5\ L\ H_2 \left(\frac{1\ mol\ CH_4}{3\ mol\ H_2}\right) = 213\ L\ CH_4$

7. Using the MO diagram provided, determine the bond order and para/diamagnetism of $O_2^{3-}$.

(A) 1.0 and paramagnetic
(B) 1.0 and diamagnetic
(C) 1.5 and paramagnetic
(D) 0.5 and diamagnetic
(E) 0.5 and paramagnetic




Partial Credit:
C = 2 pts

8. A steel gas cylinder contains argon gas at STP. What is the final pressure if the temperature is changed to 145°C?

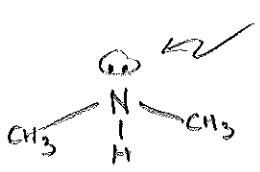
(A) 0.653 atm
(B) 0.713 atm
(C) 1.40 atm
(D) 1.53 atm
(E) 5.80 atm

$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$ $\quad \frac{1\ atm}{273.15\ K} = \frac{P_2}{(273.15K + 145)}$

$P_2 = 1.53\ atm$

9. Which of the following is correct for the nitrogen in $CH_3NHCH_3$?

| | | | |
|---|---|---|---|
| (A) | $sp^2$ | eg=trigonal planar | mg=trigonal planar |
| (B) | $sp^3$ | eg=trigonal planar | mg=trigonal planar |
| (C) | $sp^2$ | eg=tetrahedral | mg=trigonal planar |
| (D) | $sp^3$ | eg=tetrahedral | mg=trigonal planar |
| (E) | $sp^3$ | eg=tetrahedral | mg=trigonal pyramidal |




$sp^3$
eg = Td
mg = trigonal pyramidal

10. Which of the following pure compounds exhibits hydrogen bonding?

H-O
H-N
H-F

(A) $CH_3Cl$
(B) HI
(C) $CH_3OCH_3$
(D) $NH_3$
(E) $CH_2CF_2$

11. The normal boiling point for $CH_3CH_2CH_2CH_3$ is greater than the normal boiling point for $CH_3CH_3$. This can be explained by:

Both nonpolar

(A) larger dipole-dipole forces
(B) larger dispersion forces
(C) larger hydrogen-bond forces
(D) larger dipole-dipole forces, larger dispersion forces, and larger hydrogen-bond forces
(E) larger dipole-dipole forces and larger hydrogen-bond forces

12. A Himalayan mountain climber needs to melt 2.00 kg of ice at 0 °C for drinking water. She has small cylinders of camping gas that provide 155 kJ energy each. How many cylinders will she need to melt the ice?

$q = m\Delta H_f = (2000g)(334\ J/g) = 668{,}000\ J$

(A) 1
(B) 3
(C) 5
(D) 7
(E) 9

$\frac{668{,}000\ J}{155{,}000\ J} = 4.31$ or 5 cylinders

13. Which of the following pairs of reactants would you expect to produce a precipitate in aqueous solution?

(A) NaCl(aq) and KOH(aq)
(B) $NH_4OH(aq)$ and $BaCl_2(aq)$
(C) NaCl(aq) and $AgNO_3(aq)$
(D) $Na_2CO_3(s)$ and $NH_4Cl(aq)$
(E) $K_2SO_4(aq)$ and $NH_4OH(aq)$

$Ba^{2+}_{(aq)} + 2\,OH^-_{(aq)} \rightarrow Ba(OH)_{2(s)}$ ↓

$CaCO_3$ MM = 100.0 g/mol

14. What mass of calcium carbonate should be dissolved in water to produce 500.0 mL of a 0.200 M solution?

(A) 0.100 g
(B) 0.100 kg
(C) 10.0 g
(D) 1.00 g
(E) 1.00 kg

$M = \frac{mol}{L}$

$0.200\,M = \frac{mol}{0.5000\,L}$

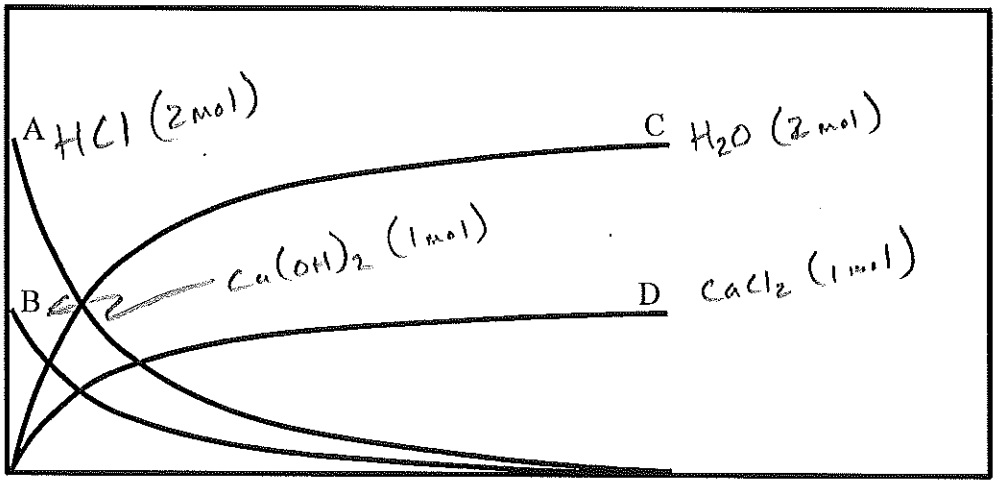
$mol = 0.100\ mol$

$0.100\ mol \left(\frac{100.0\ g}{1\ mol}\right) = 10.0\ g$

15. For the following reaction:

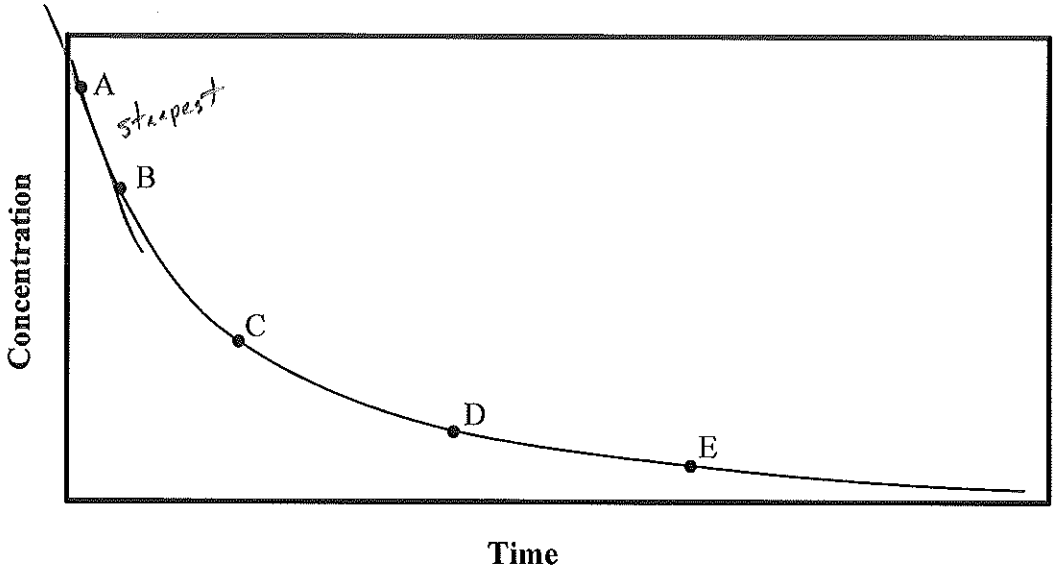
$$Ca(OH)_2 + 2\,HCl \longrightarrow CaCl_2 + 2\,H_2O$$

Match the appropriate concentration –vs-time profile with the appropriate compound.




| | | | | |
|---|---|---|---|---|
| (A) | A=$Ca(OH)_2$ | B=HCl | C=$CaCl_2$ | D=$H_2O$ |
| (B) | B=$Ca(OH)_2$ | A=HCl | C=$CaCl_2$ | D=$H_2O$ |
| (C) | A=$Ca(OH)_2$ | B=HCl | D=$CaCl_2$ | C=$H_2O$ |
| (D) | A=$Ca(OH)_2$ | D=HCl | C=$CaCl_2$ | B=$H_2O$ |
| (E) | B=$Ca(OH)_2$ | A=HCl | D=$CaCl_2$ | C=$H_2O$ |

16. In the reaction graph shown below, at which point is the reaction rate the greatest?




(A) A
(B) B
(C) C
(D) D
(E) E

17. What are the units of k in the following rate law? Rate = k[X][Y]

(A) $\frac{M}{s}$

(B) Ms

(C) $\frac{1}{Ms}$

(D) $\frac{M^2}{s}$

(E) $\frac{s}{M^2}$

$\frac{M}{s} = k(M)(M)$

$k = \frac{1}{M \cdot s}$

18. Given the following rate law, how does the rate of reaction change if the concentration of X is doubled and Y is tripled?

Rate = k [X][Y]$^2$

Rate = $k(2)(3)^2 = 18k$

(A) The rate of reaction will increase by a factor of 2
(B) The rate of reaction will increase by a factor of 5
(C) The rate of reaction will increase by a factor of 9
(D) The rate of reaction will increase by a factor of 18
(E) The rate of reaction will decrease by a factor of 5

Partial Credit: B = 2 pts

19. Which of the following statements is **FALSE**?

(A) When $K_c >> 1$, the forward reaction is favored and essentially goes to completion. ✓

(B) When $K_c << 1$, the reverse reaction is favored and the forward reaction does not proceed to a great extent. ✓

(C) When $K_c \approx 1$, neither the forward or reverse reaction is strongly favored, and about the same amount of reactants and products exist at equilibrium. ✓

(D) $K_c >> 1$ implies that the reaction is very fast at producing products.

(E) None of the above are false.

(No — $K_c$ is not an indicator of rate)

20. Express the equilibrium constant for the following reaction.

$$2\,Na(s) + 2\,H_2O(l) \leftrightarrow 2\,NaOH(aq) + H_2(g)$$

$K_c = [H_2][NaOH]^2$

(A) $K_c = \dfrac{[NaOH]^2[H_2]}{[Na]^2[H_2O]^2}$

(B) $K_c = \dfrac{[H_2]}{[NaOH]^2}$

(C) $K_c = \dfrac{[Na]^2[H_2O]^2}{[NaOH]^2[H_2]}$

(D) $K_c = [H_2][NaOH]^2$

(E) $K_c = \dfrac{[NaOH]^{1/2}[H_2]}{[Na]^{1/2}[H_2O]^{1/2}}$

21. The equilibrium constant is given for one of the reactions below. Determine the value of the missing equilibrium constant.

$H_2(g) + Br_2(g) \leftrightarrow 2\ HBr(g)\ K_c = 3.8 \times 10^4$

$2\ HBr(g) \leftrightarrow H_2(g) + Br_2(g)\ K_c = ?$

$\frac{1}{3.8 \times 10^4} = 2.6 \times 10^{-5}$

(A) $1.9 \times 10^4$
(B) $5.3 \times 10^{-5}$
(C) $2.6 \times 10^{-5}$
(D) $6.4 \times 10^{-4}$
(E) $1.6 \times 10^3$

22. Consider the system $SO_2(g) + CO_2(g) \leftrightarrow CO(g) + SO_3(g)$ $K_c = 6.76$

A student prepares the system and measures:

$[SO_2] = 1.03$ M $[CO_2] = 1.22$ M $[CO] = 2.93$ M $[SO_3] = 2.90$ M

(A) The system is at equilibrium.
(B) The system is not at equilibrium and more product will form.
(C) The system is not at equilibrium and more reactant will form.
(D) The system is not at equilibrium and you will need to add more product.
(E) The system is not at equilibrium and you will need to add more reactant.

$Q = \frac{P}{r} = \frac{(2.93)(2.90)}{(1.03)(1.22)} = 6.76$ Q = K Equilibrium

23. What is the pH of 0.750 M $CH_3COOH$ (aq)?

| | $CH_3COOH(aq)$ | $\rightleftharpoons$ | $CH_3COO^-(aq)$ | + | $H^+(aq)$ |
|---|---|---|---|---|---|
| I | 0.750 | | 0 | | 0 |
| C | $-x$ | | $+x$ | | $+x$ |
| E | $0.750 - x$ | | $x$ | | $x$ |

(A) 0.750
(B) 0.00367
(C) 2.43
(D) 1.75
(E) 6.25

$K_a = 1.80 \times 10^{-5} = \frac{x^2}{0.750}$

$x = [H^+] = 0.00367$

$pH = -\log(0.00367) = 2.43$

24. For the following chemical equilibrium, which of the following statements are correct?

$CO_{(g)} + Cl_{2(g)} \rightleftharpoons COCl_{2(g)}$ $K_c = 1.5 \times 10^4$ and $\Delta H = -243$ kJ/mole

2 mol → 1 mol ; ↑ exothermic

(A) Increasing the pressure will create more products
(B) Increasing the pressure will create more reactants
(C) Increasing the temperature will create more products
(D) Decreasing the pressure will create more products
(E) Decreasing the temperature will create more reactants

25. Which of the following is an Arrhenius base?

(A) $CH_3CO_2H$
(B) LiOH $LiOH \rightarrow Li^+ + OH^-$
(C) $CH_3OH$
(D) NaBr
(E) More than one of these compounds is an Arrhenius base.

26. Which of the following species is amphoteric?

can accept & donate $H^+$

(A) $CO_3^{2-}$
(B) HF
(C) $NH_4^+$
(D) $HPO_4^{2-}$
(E) None of the above are amphoteric.

$HPO_4^{2-} \rightleftharpoons PO_3^{3+} + H^+$

$HPO_4^{2-} + H^+ \rightleftharpoons H_2PO_4^-$

27. What is the conjugate acid of $HCO_3^-$ ?

(A) $H_3O^+$
(B) $H_2O$
(C) $CO_3^{2-}$
(D) $OH^-$
(E) $H_2CO_3$

$HCO_3^- + H_2O \rightleftharpoons H_2CO_3 + OH^-$

Base — conjugate acid

Partial Credit:
C = 2 pts

28. The stronger the acid, then which of the following is TRUE?

(A) The stronger the conjugate acid.
(B) The stronger the conjugate base.
(C) The weaker the conjugate base.
(D) The weaker the conjugate acid.
(E) None of the above.

$HCl \longrightarrow H^+ + Cl^-$

Strong Acid — weak conjugate base

29. Which of the following solutions would have the highest pH? Assume that they are all 0.10 M in acid at 25°C. The acid is followed by its $K_a$ value.

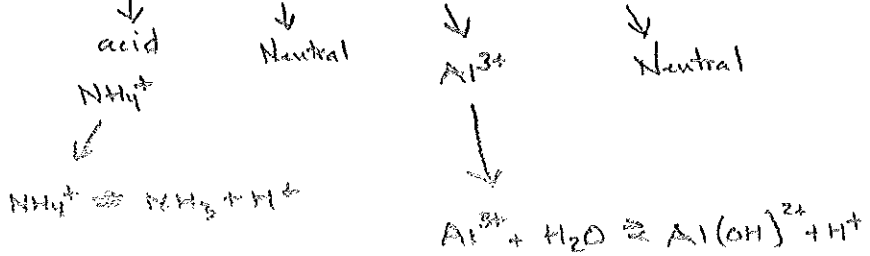
↓ weakest acid

(A) HF, $3.5 \times 10^{-4}$
(B) HCN, $4.9 \times 10^{-10}$
(C) $HNO_2$, $4.6 \times 10^{-4}$
(D) HCOOH, $1.8 \times 10^{-4}$
(E) $HClO_2$, $1.1 \times 10^{-2}$

Partial Credit:
E = 2 pts

30. Which solution(s) is (are) expected to be neutral pH? $NH_4Br$ (aq), KBr (aq), $AlBr_3$ (aq), or $KNO_3$ (aq)?

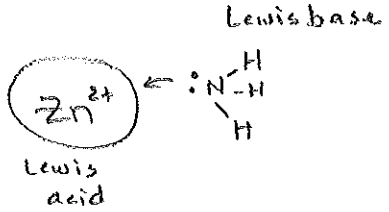
a. $NH_4Br$ (aq) only
b. KBr (aq) only
c. $AlBr_3$ (aq) only
d. $KNO_3$ (aq) only
e. $KNO_3$ (aq) and KBr (aq)




31. Which of the following statements is **true** in this reaction:

$Zn^{2+}$ (aq) + 4 $NH_3$ (aq) ⇄ $Zn(NH_3)_4^{2+}$ (aq)

a) $Zn^{2+}$ (aq) is the Lewis acid in this reaction.
b) $NH_3$ (aq) is the Lewis acid in this reaction.
c) $Zn(NH_3)_4^{2+}$ (aq) is the Lewis acid in this reaction.
d) Both $Zn^{2+}$ (aq) and $NH_3$ (aq) are Lewis acids in this reaction.
e) There are no Lewis acids in this reaction.




32. Carbon dioxide ($CO_2$) dissolves in water according to the equations:

$CO_2$ (g) + $H_2O$ (l) ⇄ $H_2CO_3$ (aq)
$H_2CO_3$ (aq) + $H_2O$ (l) ⇄ $HCO_3^-$ (aq) + $H_3O^+$ (aq)  pH ↓

$CO_2$ levels in the atmosphere have increased about 20% over the last century. Given that Earth's oceans are exposed to atmospheric $CO_2$, which of the following best predicts the effects of increased $CO_2$ levels on the pH of the Earth's oceans now?

a) The pH of Earth's oceans now is higher than the pH of Earth's oceans a century ago.
b) The pH of Earth's oceans now is the same as the pH of Earth's oceans a century ago.
c) The pH of Earth's oceans now is lower than the pH of Earth's oceans a century ago.
d) The increase in $CO_2$ levels in Earth's oceans has no effect on its pH level.