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	$k_f(H_2O) = 1.86$ ºC/m	$k_b(H_2O) = 0.512$ ºC/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)	ΔH(fusion) (J/g)	BP (°C)	ΔH(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

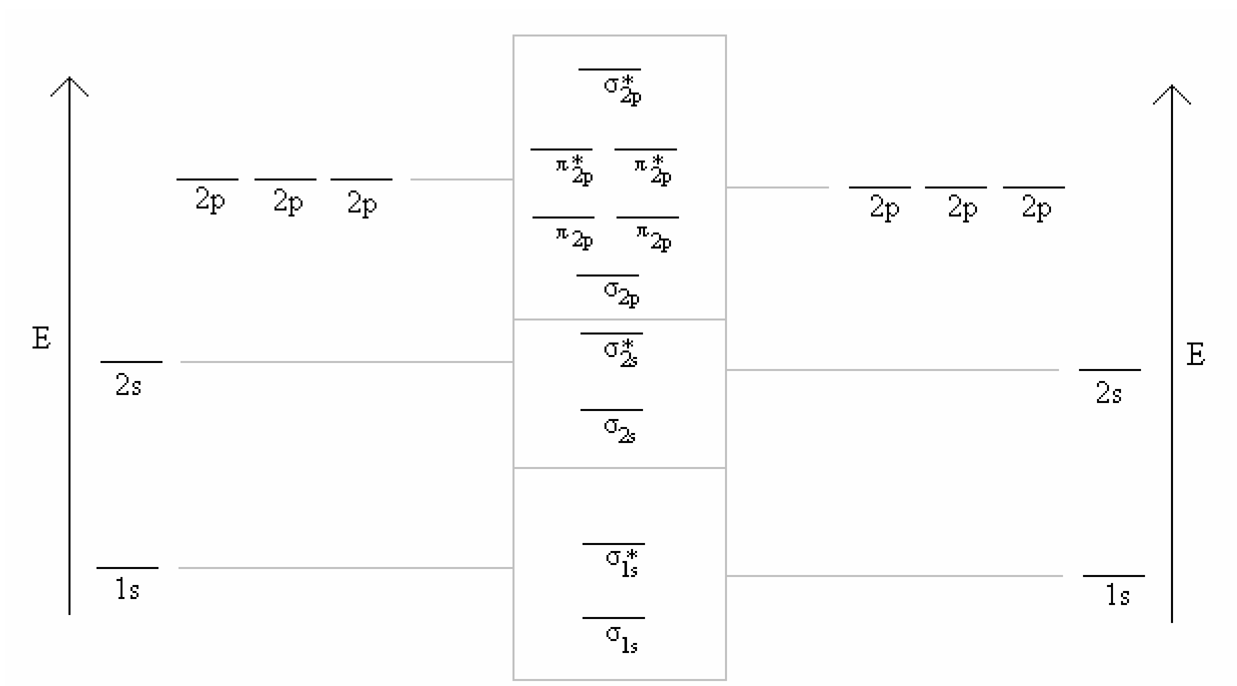
1 **H** Hydrogen 1.00794																	2 **He** Helium 4.003
3 **Li** Lithium 6.941	4 **Be** Beryllium 9.012182											5 **B** Boron 10.811	6 **C** Carbon 12.0107	7 **N** Nitrogen 14.00674	8 **O** Oxygen 15.9994	9 **F** Fluorine 18.9984032	10 **Ne** Neon 20.1797
11 **Na** Sodium 22.989770	12 **Mg** 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	$\dfrac{P_1V_1}{n_1T_1} = \dfrac{P_2V_2}{n_2T_2}$	$\mu_{rms} = \sqrt{\dfrac{3RT}{Molar\ Mass}}$
R = 0.08206 $\dfrac{L \bullet atm}{mol \bullet K}$	R = 8.314 $\dfrac{kg \bullet m^2}{s^2 \bullet mol \bullet K}$	760 Torr = 1 atm = 760 mm Hg
K = 273.15 + °C	1 mole = 6.02 x 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.

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

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?

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

(A) 192 L
(B) 213 L
(C) 1280 L
(D) 638 L
(E) 1920 L

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

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

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

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

(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:

(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 all the ice?

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

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) $NaNO_3$(aq) and $AgNO_3$(aq)
(D) Na_2CO_3(s) and NH_4Cl(aq)
(E) K_2SO_4(aq) and NH_4OH(aq)

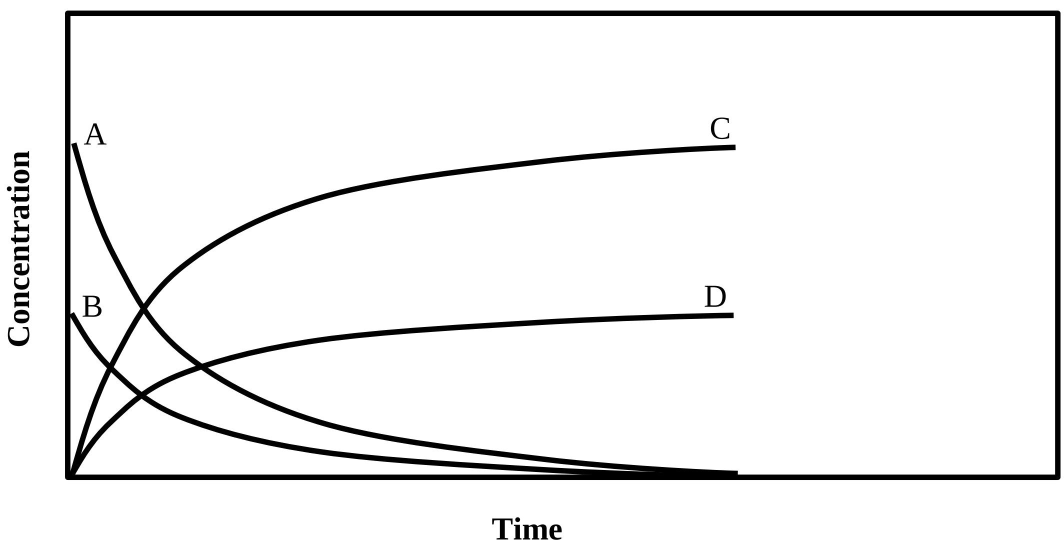
14. What mass of calcium carbonate should be dissolved in water to produce 500.0 mL of a 0.200 M solution?

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

15. For the following reaction:

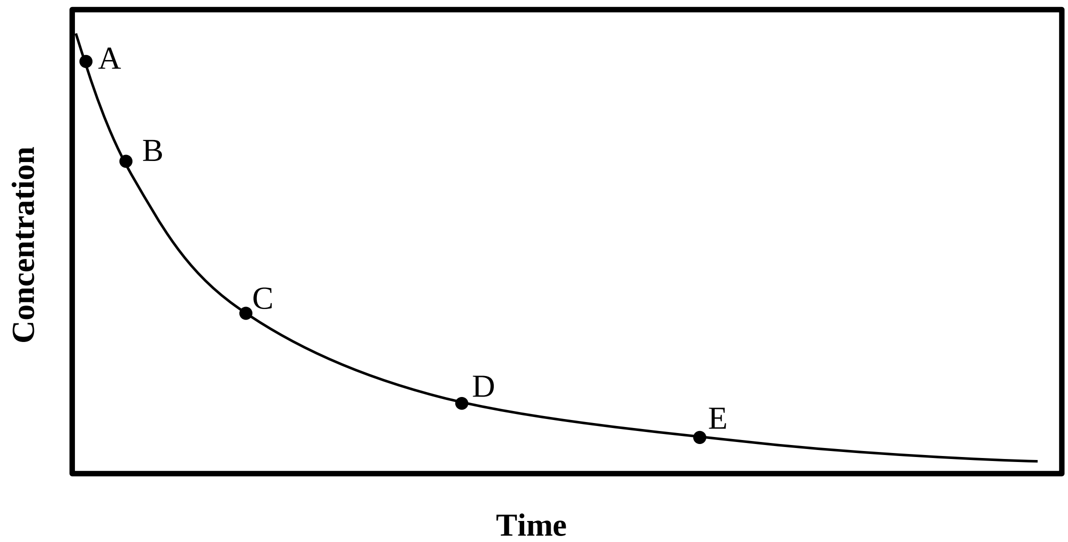
$$Ca(OH)_2 + 2\ HCl \longrightarrow CaCl_2 + 2\ H_2O$$

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

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

(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

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.

20. Express the equilibrium constant for the following reaction.

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

(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.

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

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

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.

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

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

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

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

(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_3COOH
(B) LiOH
(C) CH_3OH
(D) NaBr
(E) More than one of these compounds is an Arrhenius base.

26. Which of the following species is amphoteric?

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

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

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.

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.

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

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) $\rightleftarrows$ $Zn(NH_3)_4^{2+}$ (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) $\rightleftarrows$ H_2CO_3 (aq)
H_2CO_3 (aq) + H_2O (l) $\rightleftarrows$ HCO_3^- (aq) + H_3O^+ (aq)

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.