Day 1: 25 Multiple Choice questions
25 points   Section I Part A and B Practice

Start: Answer all questions on this day before stopping.

Note: NO CALCULATORS may be used for questions on this day.

You may use ONLY the Periodic Table provided on page 337

Note: For all questions, assume that the temperature is 298 K, the pressure is 1.00 atmosphere and solutions are aqueous unless otherwise noted.

Questions 1 through 3 refer to the following gases:

(A) HCl
(B) O_2
(C) NO
(D) NO_2
(E) CO

1. This gas diffuses at the slowest rate.

2. This gas has the most weakly interacting molecules.

3. At any given temperature and pressure, this gas has particles with the highest average velocity.

Questions 4 through 7 refer to the following hybridizations:

(A) sp
(B) sp^2
(C) sp^3
(D) sp^3d
(E) sp^3d^2

4. SO_2

5. I_3^-

6. IF_5

7. CH_3OH

8. $Zn(s)$ + $2AgNO_3(aq)$ ------> $2Ag(s)$ + $Zn(NO_3)_2(aq)$

According to the reaction represented above, about how many grams of zinc must go into this reaction to produce 1.0 mol of silver?

(A) 17 g
(B) 25 g
(C) 33 g
(D) 65 g
(E) 130 g

9. When a gas expands from 5.00 to 6.00 liters at a constant pressure of 2.00 atm, it absorbs 505.64 joules of energy. What is the change in energy, ΔE, for the gas? (101.32 joules = 1 liter. atm)

(A) 50.66 J
(B) 101.32 J
(C) 303.00 J
(D) 505.64 J
(E) 606.00 J

10. According to Raoult's Law, which statement is incorrect?

(A) The vapor pressure of a solvent decreases as its mole fraction increases.
(B) Ionic solids ionize in water, increasing the effects of all colligative properties.
(C) The vapor pressure of a solvent over a solution is less than that of the pure solvent
(D) The solubility of a gas increases as the temperature decreases.
(E) The solubility of a gas in solution increases as the pressure of the gas increases.

11. A molecule of H–Cl contains how many lone electron pairs?

(A) one
(B) two
(C) three
(D) four
(E) six

12. $MgO(s)$ + $H_2(g)$ <--> $Mg(s)$ + $H_2O(g)$ $\Delta H = -14.0$ kilojoules
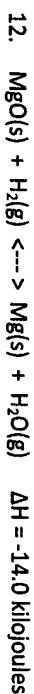
When the substances in the equation above are at equilibrium at pressure (P) and temperature (T), the equilibrium can be shifted to favor the products by

(A) increasing the pressure in the reaction vessel while keeping the temperature constant.
(B) increasing the pressure by adding an inert gas such as argon.
(C) allowing some hydrogen gas to escape at constant P and T
(D) decreasing the temperature.
(E) adding a catalyst.

13. Which of the following solutions has the highest boiling point?

(A) 0.10 m oxalic acid, $H_2C_2O_4$
(B) 0.10 m potassium chloride, KCl
(C) 0.10 m ammonium nitrate, NH_4NO_3
(D) 0.10 m sucrose, $C_{12}H_{22}O_{11}$
(E) 0.10 m calcium nitrate, $Ca(NO_3)_2$

14. 100 grams of $O_2(g)$ and 100 grams of $He(g)$ are in separate containers of equal volume. Both gases are at 100°C. Which one of the following statements is true?

(A) Both gases would have the same pressure.
(B) The average kinetic energy of the O_2 molecules is greater than that of the He molecules.
(C) The average kinetic energy of the He molecules is greater than that of the O_2 molecules.
(D) There are equal numbers of He molecules and O_2 molecules.
(E) The pressure of the He(g) would be greater than that of the $O_2(g)$.

15. Which of the following elements is not isoelectronic with the others?

(A) S^{2-}
(B) Cl^-
(C) Ar
(D) K^+
(E) Mg^{2+}

16. A 1-molar solution of a very weak monoprotic acid has a pH of 5. What is the value of k_a for the acid?

(A) $K_a = 1 \times 10^{-10}$

(B) $K_a = 1 \times 10^{-7}$

(C) $K_a = 1 \times 10^{-5}$

(D) $K_a = 1 \times 10^{-2}$

(E) $K_a = 1 \times 10^{-1}$

17. Carbon-14 has a half-life of 5730 years. Approximately what percent of the original radioactivity would be present after 34,480 years?

(A) 1.56%

(B) 3.13%

(C) 6.26%

(D) 12.5%

(E) 25.0%

18. Which of the following statements is true regarding magnesium and calcium?

(A) Magnesium has a larger first ionization energy and a larger atomic radius

(B) Magnesium has a larger first ionization energy and a smaller atomic radius

(C) Magnesium has a smaller first ionization energy and a larger atomic radius

(D) Magnesium has a smaller first ionization energy and a smaller atomic radius

(E) Magnesium and calcium have identical first ionization energies and atomic radii

19. What are the oxidation numbers of chromium in chromate and dichromate anions, respectively?

(A) +8, +14

(B) +8, +7

(C) +7, +7

(D) +6, +6

(E) +4, +7

---

20. For which of the following processes would ΔS have a positive value?

I. $MgCO_3(s) \longrightarrow MgO(s) + CO_2(g)$

II. $Ba^{2+}(aq) + SO_4^{2-}(aq) \longrightarrow BaSO_4(s)$

III. $Cl_2(g) + C_3H_6(g) \longrightarrow C_3H_6Cl_2(g)$

(A) I only

(B) I and II only

(C) I and III only

(D) II and III only

(E) I, II, and III

21. At 37°C and 1.00 atm of pressure, nitrogen gas dissolves in the blood at a solubility of 6.0×10^{-4} M. If a diver breathes compressed air where nitrogen gas constitutes 80. mole % of the gas mixture, and the total pressure at this dept is 3.0 atm, what is the concentration of nitrogen gas in her blood?

(A) 1.4×10^{-4} M

(B) 6.0×10^{-4} M

(C) 1.0×10^{-3} M

(D) 1.4×10^{-3} M

(E) 6.0×10^{-3} M

22. The rate law for a chemical reaction between substances A and B is

$$rate = k [A]^2[B]$$

where k is constant. To make the reaction proceed at 50% of its original rate, the concentration of A is reduced to half its original. To make the reaction proceed at 50% of its original rate, the concentration of B should be

(A) decreased by ¼

(B) halved

(C) kept constant

(D) doubled

(E) increased by a factor of 4

23. In the titration of a weak base of unknown concentration with a solution of a strong acid, a pH meter was used to follow the progress of the titration. Which of the following graphs best represents the data collected for this experiment?

(A)

pH graph with axes pH (2, 7, 12) vs ml of acid added

(B)

pH graph with axes pH (2, 7, 12) vs ml of acid added

(C)

pH graph with axes pH (2, 7, 12) vs ml of acid added

(D)

pH graph with axes pH (2, 7, 12) vs ml of acid added

(E)

pH graph with axes pH (2, 7, 12) vs ml of acid added
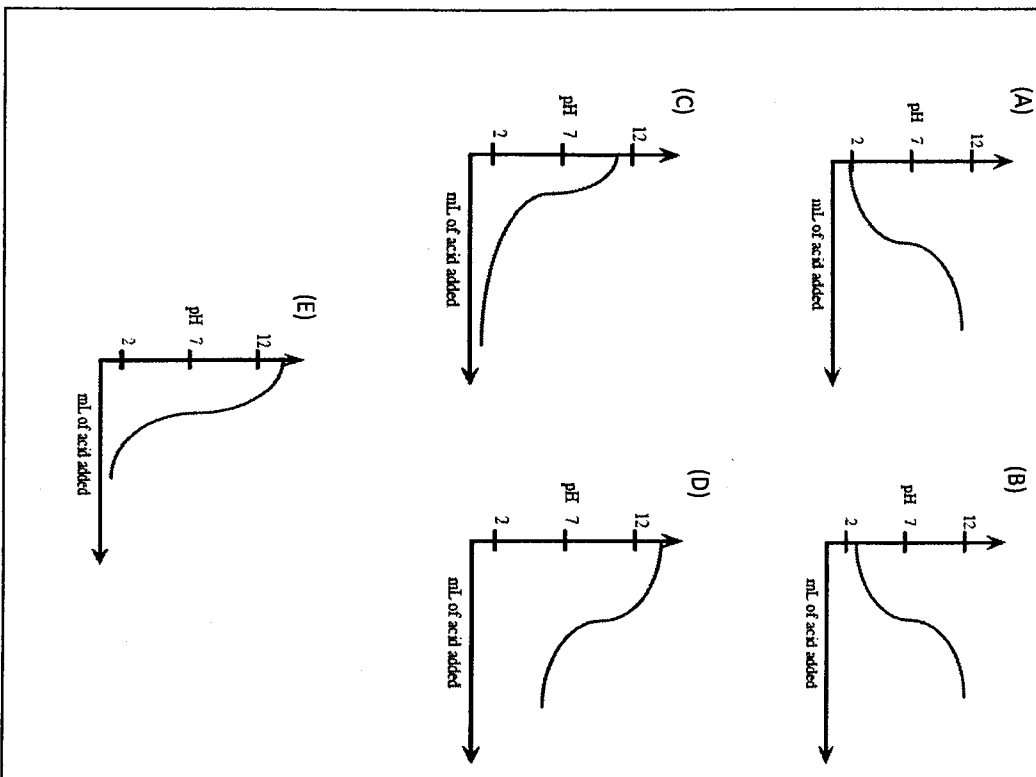
24. Which correctly represents the electron configuration of an oxide ion?

(A) $1s^2 2s^2 2p^2$
(B) $1s^2 2s^2 2p^4$
(C) $1s^2 2s^2 2p^6$
(D) $1s^2 2s^2 2p^6 3s^2$
(E) $1s^2 2s^2 2p^6 3s^2 3p^6$

25.

Phase diagram: Pressure (atm) vs Temperature (degrees Celsius). Pressure values 1.0, 5.1, 72.8. Temperature values -78, -56.6, 31. Points A and B marked.
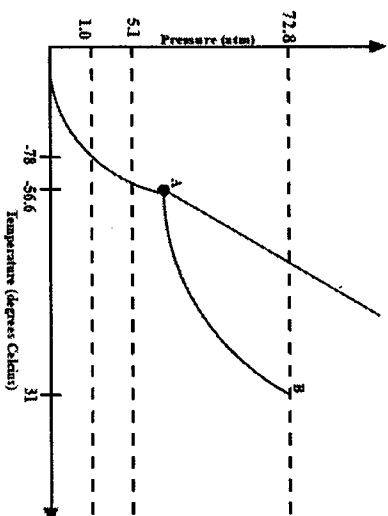
The normal boiling point of the substance represented by the phase diagram above is

(A) -78°C
(B) -56.6°C
(C) 31°C
(D) greater than 31°C
(E) not determinable from the diagram

STOP. Correct your answers and note how many correct **points**

Day 2: 2 Free Response Questions
20 points *Section II Part A Practice*

START: Answer all questions on this day before stopping.

Note: You may use a calculator for answering questions on this day
You may use any of the Reference Material provided on pg 337-340

CLEARLY SHOW THE METHOD USED AND THE STEPS INVOLVED IN ARRIVING
AT YOUR ANSWERS. It is to your advantage to do this, since you may obtain
partial credit if you do and you will receive little or no credit if you do not.
Attention should be paid to significant figures.

1.
10 points
Formic acid is a significant component of bee venom. Also known as
methanoic acid, formic acid has an acid dissociation constant, K_a, of
1.80×10^{-4}.

a) If a bottle contains 0.25M solution of formic acid.
  (i) Write the equilibrium expression for the dissociation of the acid.

  (ii) Calculate the pOH of the solution.

b) Calculate the percent dissociation of the solution in part (a).

c) Calculate the pH of a solution prepared by mixing equal 1.00L
  volumes of 0.25M formic acid and 0.20M sodium methanoate.

d) Using only compounds already mentioned, what should be added to
  the solution in part (c) to produce a solution with maximum capacity
  to resist change in pH?

  Mention
  (i) The compound to be added.

  (ii) The mass of the compound to be added.

2.

Refer to the following equation.

10 points

$$2Mg(s) + 2CuSO_4(aq) + H_2O(l) \longrightarrow 2MgSO_4(aq) + Cu_2O(s) + H_2(g)$$

a) If 1.46 grams of Mg(s) are added to 500 mL of a 0.200 M solution of $CuSO_4$, what is the maximum molar yield of $H_2(g)$?

b) When all the limiting reagent has been consumed in (a), how many grams of the other reactant (not water) remain?

c) What is the mass of the Cu_2O produced in (a)

d) What is the concentration of Mg^{2+} in the solution at the end of the experiment? Assume that the volume of the solution remains unchanged.

Day 2

STOP. Correct your answers and note how many correct **points**

Day 2 Question 2: Space for Work and Answers

Day 3: 2 Free Response Questions
23 points
Section II Part B practice

START: Answer all questions on this day before stopping.

Note: **NO CALCULATORS should be used for questions on this day.**
You may use any of the Reference Materials provided on Pg 337-340

1. For each of the following three reactions, write a balanced equation for the reaction in part (i) and answer the question about the reaction in part (ii). In part (i), coefficients should be in terms of lowest whole numbers. Assume that solutions are aqueous unless otherwise indicated. Represent substances in solutions as ions if the substances are extensively ionized. Omit formulas for any ions or molecules that are unchanged by the reaction.

15 points

(a) A piece of solid tin is heated in the presence of chlorine gas.

(i) Balanced equation:

(ii) What is the oxidation number of the tin before and after the reaction?

(b) Ethane is burned completely in air.

(i) Balanced equation:

(ii) How many liters of carbon dioxide will be produced from completely burning 3.4 moles of ethane at STP?

(c) A pellet of zinc is dropped into a test tube containing 30 mL of 6M HCl.

(i) Balanced equation:

(iii) Indicate two observable changes that will be noted as the reaction proceeds in the test tube.

Day 3: Continue

Your response to question 2 will be scored on the basis of the accuracy and relevance of the information cited. Explanations should be clear and well organized. Examples and equations may be included in your responses where appropriate. Specific answers are preferable to broad, diffuse responses.

8 points

2. A set of three vials contains three different organic compounds. Each compound contains only one kind of functional group, and each functional group is different from the others. None of the compounds has an ester or amide linkage, and none is an alkene or alkyne.

(a) All of the compounds possess a carbonyl group. What kinds of compounds are these three?

(b) Assuming that each of the three compounds contains four carbon atoms, and is linear (not branched), draw Lewis structures for the three compounds.

(c) Ethanol is added to each of the three vials. With which of the three compounds is ethanol most likely to react to produce an ester?

(d) Draw the Lewis structure and name the ester that would be produced in the reaction described in part (c).

Day 3

STOP. Correct your answers and note how many correct **points**

Day 3 Question 2: Space for Work and Answers