CHM2045 Exam 3 (Gower, Mitchell, Harrison, Ucak) Form Code A November 16, 2009

Instructions: On your scantron, enter your name, UF ID number, section number, and Form Code (see above). Mark your answers on your exam sheet and keep it for later reference - turn in only your scantron. **Bubbling errors of any kind will count as an incorrect response and result in loss of points.**

Potentially useful information: R = 0.0821 L•atm/mol•K and R = 8.314 J/mol•K

MO sequence (core and valence): $\sigma_{1s} < \sigma^*_{1s} < \sigma_{2s} < \sigma^*_{2s} < \pi_{2py} = \pi_{2pz} < \sigma_{2px} < \pi^*_{2py} = \pi^*_{2pz} < \sigma^*_{2px}$

1. Predict the hybridization of the central atom in each of the following molecules:

H_2CCCH_2 ; IF_4^{1-} ; IF_4^{1+} ; CH_2O

(1) ***sp^3d ; sp^2 ; sp ; sp^3d^2*** **(2)** ***sp ; sp^3d^2 ; sp^2 ; sp^3d***

(3) ***sp ; sp^3d ; sp^2 ; sp^3d^2*** **(4)** ***sp^3d^2 ; sp^3d ; sp^2 ; sp***

(5) ***sp ; sp^3d^2 ; sp^3d ; sp^2***

2. According to molecular orbital theory, what is the bond order of N_2^{1-}, C_2^{2-}, and B_2^{2+}, respectively?

(1) 1, 2, 0 (2) 5/2, 3, 0 (3) 2, 3, 1 (4) 5/2, 2, 1/2 (5) 3/2, 3, 0

3. Iridium has a face-centered cubic crystal structure and has an atomic radius of 136 pm. Calculate the density of iridium.

(1) 32.5 g/cm^3 (2) 22.4 g/cm^3 (3) 19.3 g/cm^3 (4) 18.7 g/cm^3 (5) 17.6 g/cm^3

4. Carbon tetrachloride, CCl_4, has a vapor pressure of 213 mmHg at 40°C and a vapor pressure of 836 mmHg at 80°C. What is the normal boiling point (at 760 mmHg) of CCl_4?

(1) 40°C (2) 57°C (3) 68°C (4) 77°C (5) 80°C

5. In each of the following groups of substances, pick the one that has the given property, respectively:

I. highest boiling point: HBr, Kr, Cl_2 **II. highest freezing point: H_2O, LiBr, HF**

III. lowest vapor pressure at 25°C: Cl_2, Br_2, I_2, At_2 **IV. lowest freezing point: N_2, CO, CO_2**

(1) HBr, LiBr, I_2, N_2 (2) HBr, H_2O, I_2, N_2 (3) HBr, LiBr, At_2, CO

(4) HBr, LiBr, At_2, N_2 (5) HBr, LiBr, I_2, CO

6. All of the following statements concerning molecular orbital (MO) theory are correct EXCEPT:

(1) the Pauli exclusion principle is obeyed (2) Hund's rule is obeyed

(3) the combination of two atomic orbitals creates one molecular orbital

(4) a bonding molecular orbital is lower in energy than its parent atomic orbitals

(5) electrons are assigned to orbitals of successively higher energy

7. Which of the compounds listed are not *sp^3d* hybridized at the central atom?

I. BF_3 II. AsI_5 III. SF_4 IV. BrF_5 V. XeF_4

(1) III and IV (2) I, II, and III (3) I, IV, and V (4) III and V

(5) all are *sp^3d* hybridized at the central atom

8. At 453 K and 755 mmHg, what volume of N_2 will react completely with 22.2 L H_2 to produce NH_3?

(1) 7.40 L (2) 14.8 L (3) 22.2 L (4) 44.4 L (5) 66.6 L

9. In a closed 1.00 L flask, 2.60 atm of CO reacts with 5.80 atm of O_2 according to the equation below. Assuming that the temperature remains constant, what is the final pressure in the flask?

$2\ CO(g) + O_2(g) \rightarrow 2\ CO_2(g)$

(1) 1.30 atm (2) 2.60 atm (3) 4.50 atm (4) 5.70 atm (5) 7.10 atm

10. Use molecular orbital theory to predict which species is/are paramagnetic.

(1) C_2^{2-} and N_2 (2) N_2^{1+} and B_2^{1+} (3) N_2 and Li_2 (4) Li_2 only (5) H_2^{2-} and B_2^{2-}

11. An environmental engineer analyzes a sample of air contaminated with sulfur dioxide. To a 500. mL sample of air at 700. torr and 38°C, she adds 20.00 mL of 0.01017 M aqueous iodine, which reacts as follows:

$2SO_2(g) + I_2(aq) + 2H_2O(l) \rightarrow 2HSO_4^{1-}(aq) + 2I^{1-}(aq) + 4H^+(aq)$

The excess $I_2(aq)$ left over from the above reaction was titrated with 11.37 mL of 0.0105 M thiosulfate ($S_2O_3^{2-}$) as follows: $I_2(aq) + 2S_2O_3^{2-}(aq) \rightarrow 2I^{1-}(aq) + S_4O_6^{2-}(aq)$

What is the volume % of SO_2 in the original air sample?

(1) 0.55 % (2) 0.95% (3) 1.59% (4) 2.20% (5) 2.87%

12. The root mean square velocity of a gas molecule is:

I. inversely proportional to its kinetic energy

II. directly proportional to the gas constant R

III. directly proportional to the square root of its temperature in K

IV. inversely proportional to the square root of its mass

V. directly proportional to the square root of its mass

(1) I and V (2) I and II (3) I, II, and III (4) III and IV (5) III only

13. Magnesium metal (0.100 mol) and a volume of aqueous hydrochloric acid that contains 0.500 mol of HCl are combined and react to completion according to the equation below. How many liters of hydrogen gas, measured at standard temperature and pressure (STP), are produced? $Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$

(1) 2.24 L (2) 4.48 L (3) 5.60 L (4) 11.2 L (5) 22.4 L

14. Which of the following substances will have hydrogen bonds between molecules?

(1) $(CH_3)N$ (2) CH_3OCH_3 (3) CH_3CH_2OH (4) CH_3CH_2F (5) HI

15. A 0.0125 g sample of a gas with an empirical formula of CHF_2 is placed in a 165 mL flask. It has a pressure of 13.7 mmHg at 22.5 °C. What is the molecular formula of the compound?

(1) CHF_2 (2) $C_2H_2F_4$ (3) $C_3H_3F_6$ (4) $C_4H_4F_8$ (5) $C_5H_5F_{10}$

16. Which of the following pairs is arranged with the particle of higher polarizability listed first?

(1) Se^{2-}, S^{2-} (2) I, I^- (3) Mg^{2+}, Mg (4) Br, I (5) none of these

17. A 3.0 L sample of helium gas was placed in a container filled with a porous membrane. Half of the helium gas effused through the membrane in 24 hours. A 3.0 L sample of oxygen gas was placed in an identical container. How many hours will it take for half of the oxygen gas to effuse through the membrane?

(1) 8.5 h (2) 12 h (3) 48 h (4) 60. h (5) 68 h

18. Which one of the following statements about orbital hybridization is <u>not</u> correct?

(1) the carbon atom in CH_4 is sp^3 hybridized
(2) the carbon atom in CO_2 is *sp* hybridized
(3) the nitrogen atom in NH_3 is sp^2 hybridized
(4) sp^2 hybrid orbitals are coplanar, and at 120° to each other
(5) *sp* hybrid orbitals lie at 180° to each other

19. Based on molecular orbital theory, which of the following 2nd-period homonuclear diatomic species is the most stable?

(1) N_2 (2) Be_2 (3) C_2 (4) Li_2 (5) B_2

20. Liquid ammonia (boiling point is –33.4°C) can be used as a refrigerant and heat transfer fluid. How much energy is needed to heat 25.0 g of $NH_3(l)$ from –65.0°C to –12.0°C? (specific heat capacity of $NH_3(l)$ = 4.7 J/g•K; specific heat capacity of $NH_3(g)$ = 2.2 J/g•K; ΔH_{vap} of NH_3 = 23.5 kJ/mol)

(1) 5.5 kJ (2) 5.3 kJ (3) 39 kJ (4) 340 kJ (5) 590 kJ

21. How many sigma (σ) and pi (π) bonds are in a molecule of acetone, $(CH_3)_2CO$?

(1) 10 σ, 0 π (2) 8 σ, 1 π (3) 8 σ, 2 π (4) 9 σ, 1 π (5) 9 σ, 2 π

22. Liquid nitrogen trichloride is heated in a 2.50 L closed reaction vessel until it decomposes completely to $N_2(g)$ and $Cl_2(g)$ products. The resulting mixture exerts a pressure of 754 mmHg at 95°C. What is the partial pressure of Cl_2 in the mixture?

(1) 188 mmHg (2) 566 mmHg (3) 754 mmHg (4) 94 mmHg (5) 660 mmHg

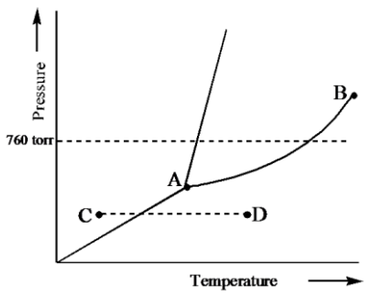
23. A 1.20 g sample of water is injected into an evacuated 5.00 L flask at 65°C. What percentage of the water will be vapor when the system reaches equilibrium? (The vapor pressure of water at 65°C is 187.5 mmHg)

(1) 33.2 % (2) 48.5 % (3) 54.6 % (4) 66.8 % (5) 75.8 %

24. A 3.0 L flask containing helium at 145 mmHg is connected by a closed valve to a 2.0 L flask containing argon at 355 mmHg. When the valve is opened and the gases are allowed to mix equally in the two flasks, what is the total pressure in the two connected flasks after mixing? (Assume constant temperature)

(1) 230 mmHg (2) 500 mmHg (3) 190 mmHg (4) 434 mHg (5) 130 mmHg

25. Consider the following phase diagram and identify the process occurring as one goes from point C to point D.



(1) increasing temperature with a phase change from solid to liquid

(2) increasing temperature with a phase change from solid to vapor
(3) increasing temperature with a phase change from liquid to vapor
(4) increasing temperature with no phase change
(5) increasing temperature beyond the critical point