Chemistry 141 Name

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Exam 2A March 31, 2009

Multiple Choice (30 points)

Page 1 (8 points)

Page 2 (16 points)

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Page 4 (21 points)

Page 5 (20 points)

Page 6 (12 points)

Total (120 points)

Chemistry Formulas

Kinetic energy = ½ mv2

w = -PΔV

Ptotal = P1+P2+P3+…

u = (3RT/MW)½

ΔG = ΔH - TΔS

PV = nRT

Rate ∝ (MW)-½

P1=X1\*Ptotal

C = q/ΔT

Ptotal = P1 + P2 + P3 + …

M = mol/L

K = oC + 273.16

w=dxF

E = mc2

HΨ=EΨ

M1V1 = M2V2

Ptotal = P1 + P2 + P3 + …

M = mol/L

Constants

h = 6.626 x 10-34 J sec

c= 2.9979 x 108 m/sec

e = 1.602 x 10-19 C

NA = 6.022 x 1023/mol

k = 1.381 x 10-23 J/K

K = oC + 273.16

1 kcal = 4.184 kJ

R = 0.0821 L atm/mol K = 62.4 L torr/mol K = 8.31 kJ/mol K

Standard Temperature and Pressure = 0oC and 1 atm

760 torr = 760 mm Hg = 1.00 atm = 101 kPa = 14.6 psi = 30 in Hg

Specific heat water = 4.184 J/g K

Specific heat Al = 0.902 J/ g K

Specific heat Cu = 0.385 J/g K

ΔHvaporization (H2O) = 2260 J/g

ΔHfusion (H2O) = 333 J/g

mass electron = 9.109 x 10-31 kg

TB07_001Part I -- Multiple choice questions (30 points)

1. Suppose you needed to closely monitor small changes in pressure inside a container using an open end manometer. For the best accuracy, the substance in the manometer should
   1. Be mercury
   2. Be a solid
   3. Have a low density
   4. Have a high density
2. In an open end manometer, one end of a U-tube filled with mercury is attached to a gas-filled container and the other end is open to the atmosphere. If the gas pressure in the container is more than atmospheric pressure
   1. the difference between the Hg levels in the two arms will be greater than 76 cm.
   2. Hg will be forced out of the open end of the U-tube.
   3. the Hg level will be higher in the arm connected to the container.
   4. the Hg level will be higher in the arm open to the atmosphere.
3. If the number of moles of gas is doubled at constant temperature and volume, the pressure of the gas
   1. Is quadrupled
   2. Is doubled
   3. Remains the same
   4. Is halved
4. . Three identical flasks contain three different gases at standard temperature and pressure. Flask A contains CH4, flask B contains CO2, flask C contains N2. Which flask has the greatest mass?
   1. flask A
   2. flask B
   3. flask C
   4. All flasks have the same mass.
5. Some assumptions from the kinetic molecular theory are listed below. Which one is most frequently cited to explain compressibility of a gas?
   1. A gas consists of tiny particles moving in random straight line motion.
   2. The volume of the particles is negligible compared to the volume of the gas.
   3. The average kinetic energy of gas particles is proportional to the Kelvin temperature.
   4. Collisions of gas particles are elastic and total kinetic energy of the gas is constant.
6. According to the kinetic molecular theory, the pressure of a gas in a container will decrease if the
   1. number of collisions with the container wall increases.
   2. temperature of the gas decreases.
   3. number of moles of the gas increases.
   4. volume of the container decreases.
7. Which of the following gases has the **highest** average speed at 400K?
   1. UF6
   2. SF6
   3. CO2
   4. N2O4
8. The nutritional calorie (abbreviated Cal) is equal to
   1. 4.184 J
   2. 4.184 cal
   3. 1 kcal
   4. 1000 kcal
9. The number of orbitals in a given subshell, such as the 5*d* subshell, is determined by the number of possible values of
   1. *l*
   2. *ml*
   3. *n*
   4. *ms*
10. Which statement about real gases is **true**?
    1. Forces of attraction and repulsion exist between gas particles at close range.
    2. The mass of the gas particles is zero.
    3. The behavior of real gases can be exactly predicted using the ideal gas law.
    4. The volume of the gas particles is zero.
11. For most chemical reactions
    1. Δ*E* is much larger than Δ*H*.
    2. Δ*H* is equal to Δ*E*.
    3. the difference between Δ*H* and Δ*E* is very small.
    4. Δ*H* is much larger than Δ*E*.
12. For a particular process that is carried out at constant pressure, *125 kJ of heat is released* and 15 kJ of work is done. Therefore,
    1. Δ*E* = −140 kJ and Δ*H* = −125 kJ.
    2. Δ*E* = −110 kJ and Δ*H* = −125 kJ.
    3. Δ*E* = −125 kJ and Δ*H* = 140 kJ.
    4. Δ*E* = −125 kJ and Δ*H* = −110 kJ.
13. The greater the energy of a photon, the
    1. longer the wavelength and the higher the frequency.
    2. longer the wavelength and the lower the frequency.
    3. shorter the wavelength and the lower the frequency.
    4. shorter the wavelength and the higher the frequency.
14. What is a quantum of light called?
    1. the amplitude
    2. the wavelength
    3. a photon
    4. the frequency
15. For an electron in a given atom, the larger *n*, the
    1. larger the average distance from the nucleus and the lower the orbital energy.
    2. smaller the average distance from the nucleus and the higher the orbital energy.
    3. larger the average distance from the nucleus and the higher the orbital energy.
    4. smaller the average distance from the nucleus and the lower the orbital energy.

Part II -- Problems (70 points)

1. (8 points) Oxygen gas is commonly sold in 30.0 L steel containers at a pressure of 150 atm.
   1. What volume (in liters) would the gas occupy at a pressure of 1.32 atm if its temperature is unchanged?
   2. What volume (in Liters) would the gas occupy if the temperature was raised from 25.0 oC to 35.0 oC at a constant pressure 150 atm?
2. (16 points) A sample of an unknown metal was reacted with 150.0 g of hydrochloric acid in a calorimeter.
   1. If a 2.744 g sample of the metal caused the temperature of the calorimeter and its contents to rise from 22.4oC to 61.2oC, calculate the heat of reaction per g for the metal. (The acid solution has a specific heat of 4.168 J/g K, and the calorimeter has a heat capacity of 39.2J/K.)
   2. The hydrogen gas from the experiment above was collected in a 397 mL at 30.0oC and 731 torr pressure, how many moles of hydrogen were collected?
   3. What is the molar mass of the metal? (Previous experiments have shown the metal to form a chloride of the formula MCl3. Write a balanced chemical reaction and determine how many moles of the metal reacted.)

M + 3 HCl 🡪 MCl3 + 3/2 H2

* 1. Calculate the molar heat of reaction of the metal.

1. (6 points) If a 0.500 mole sample of Argon requires 15.3 minutes to effuse through a porous membrane and a 0.500 mole sample of an unknown gas requires 28.8 minutes, calculate the molar mass of the unknown gas.
2. (7 points) The bombardier beetle uses an explosive discharge as a defense mechanism. The chemistry of the reaction involved is the oxidation of hydroquinone by H2O2 to produce quinone and water.

C6H4(OH)2(aq) + H2O2(aq) 🡪 C6H4O2(aq) + 2 H2O(l)

Given the following reactions, calculate ΔH.

C6H4(OH)2(aq) 🡪 C6H4O2(aq)  + H2(g)  ΔH = + 177.4 kJ

H2(g) + 1/2O2(g)  🡪 H2O(g)  ΔH = − 241.8 kJ

H2(g) + O2(g)  🡪 H2O2(aq)  ΔH = −191.2 kJ

H2O(g)  🡪 H2O(l )  ΔH = − 43.8 kJ

C6H4(OH)2(aq) 🡪 C6H4O2(aq)  + H2(g)  + 177.4 kJ

H2O2(aq)  🡪 H2(g) + O2(g)  +191.2 kJ

2(H2(g) + 1/2O2(g)  🡪 H2O(g)  ) 2(−241.8 kJ) = − 483.6 kJ

2(H2O(g)  🡪 H2O(l )) 2(−43.8 kJ) =−87.6 kJ

C6H4(OH)2(aq) + H2O2(aq) 🡪 C6H4O2(aq) + 2 H2O(l)  − 202.6 kJ

1. (8 points) An alloy with a specific heat capacity of 0.625 J/g K is heated to 555 oC and immersed into 65.00 g ice at 0.0oC. The ice melts and the resulting water warms to 36.2oC. What is the mass of the alloy?
2. (6 points) Determine the energy of the following reaction using bond dissociation energies.



|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Bonds broken |  |  | Bonds formed |  |
| C=O | + 732 kJ |  | 2 C−N | 2(−300 kJ) |
| 2 N−H | 2(+390 kJ) |  | 2 H−O | 2(−460 kJ) |
| total | +1512 kJ |  | Total | −1520 kJ |

Overall ΔH = −5 kJ/mol

1. (7 points) Microwave ovens operate by emitting microwave radiation, which is primarily absorbed by water molecules in food. The absorbed radiation is converted to heat, which cooks the food and warms beverages. If 7.2 x 1028 photons are needed to heat 140.0 g of water from 20.0oC to 100.0oC in a microwave oven, what is the frequency of the microwaves?
2. (8 points) Removing an electron from solid potassium requires 222 kJ/mol. Would you expect to observe a photoelectric effect for potassium using a photon of blue light (λ=483 nm)? Explain your reasoning

The blue light has plenty of energy to eject an electron from the potassium metal.

1. (6 points) Write the electronic configuration (shorthand) for tungsten as predicted by the periodic table. Would you predict tungsten would have an anomalous configuration? If so, show that configuration and explain why you predict this configuration.

[Xe] 6s2 5d4 4f14 (or [Xe] 4f14 5d46s2)is the configuration predicted by the periodic table

The anamolous configuration [Xe] 6s1 5d5 4f14 is predicted because it will leave ½ filled s and d orbitals

1. (6 points) Write the complete electron configuration for an atom of potassium and give a possible set of quantum numbers for the valence electron of potassium.

1s2 2s2 2p6 3s1

The valence electron will have

n = 3

l = 0

ml = 0

ms = ½

1. (4 points) Use kinetic molecular theory to explain the change in pressure that results from warming a sample of gas.

As the molecules begin to warm they move faster and exert a greater pressure on the surfaces around them.

1. (4 points) You hold a gram of copper in one hand and a gram of aluminum in the other. Each metal was originally at 0oC. (Both metals are in the shape of a little ball that fits into your hand.) If they both take up heat at the same rate, which will warm to your body temperature first? Explain your reasoning.

The copper will warm to your body temperature faster because it takes less heat to change the temperature of copper than aluminum as evidenced by their specific heats.

Must specify different amounts of heat to change temperature. If no mention of temp then -2 points.

Specific heat Al 0.902 J/g K

Specific heat Cu 0.385 J/g K

1. (4 points) What physical meaning is attributed to the square of the wave function ψ2?

ψ2 describes the probability function for an orbital. It describes the region in space where the electron has a high probability of existing.