Chemistry 141 Name

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Exam 2B March 24, 2011

Multiple Choice (30 points)

Page 1 (19 points)

Page 2 (17 points)

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Page 4 (16 points)

Page 5 (20 points)

Total (117 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

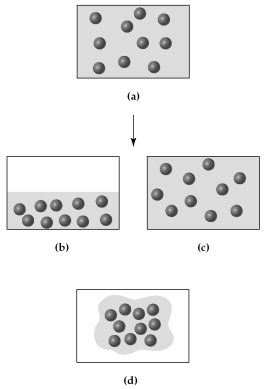
ΔHvaporization (H2O) = 2260 J/g

ΔHfusion (H2O) = 333 J/g

mass electron = 9.109 x 10-31 kg

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Average Bond dissociation Energies (kJ/mol) | | | | |
| H—H 436\* | C—H 410 | N—H 390 | O—H 460 | F—F 159\* |
| H—C 410 | C—C 350 | N—C 300 | O—C 350 | Cl—Cl 243\* |
| H—F 570\* | C—F 450 | N—F 270 | O—F 180 | Br—Br 193\* |
| H—Cl 432\* | C—Cl 330 | N—Cl 200 | O—Cl 200 | I—I 151\* |
| H—Br 366\* | C—Br 270 | N—Br 240 | O—Br 210 | S—F 310 |
| H—I 298\* | C—I 240 | N—I | O—I 220 | S—Cl 250 |
| H—N 390 | C—N 300 | N—N 240 | O—N 200 | S—Br 210 |
| H—O 460 | C—O 350 | N—O 200 | O—O 180 | S—S 225 |
| H—S 340 | C—S 260 | N—S | O—S 364 |  |
|  |  |  |  |  |
| C=C 611 | C=O 732 | O=O 498\* | O=S 535 | N=O 598 |
| C≡C 837 | C≡N 891 | N≡N 946\* |  |  |
| \*Bond dissociation energies for diatomic molecules are exact. | | | | |

TB07_001Part I -- Multiple choice questions (30 points)

1. According to the kinetic molecular theory, the pressure of a gas in a container will increase if the
   1. number of collisions with the container wall decreases.
   2. temperature of the gas increases.
   3. number of moles of the gas decreases.
   4. volume of the container increases.
2. Which statement about real gases is **true**?
   1. The mass of the gas particles is zero.
   2. The behavior of real gases can be exactly predicted using the ideal gas law.
   3. Forces of attraction and repulsion exist between gas particles at close range.
   4. The volume of the gas particles is zero.
3. Assume that you have a sample of gas at 300 K in a sealed container, as represented in (a).

Which of the drawings (b)-(d) represents the gas after the temperature is lowered from 300 K to 200 K?

* 1. Drawing b
  2. Drawing c
  3. Drawing d

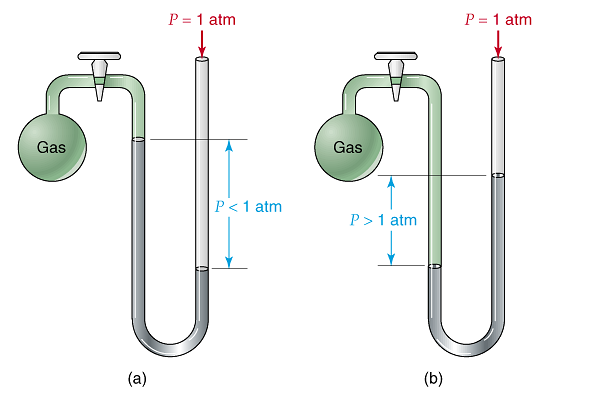
1. The nutritional calorie (abbreviated Cal) is equal to
   1. 4.184 J
   2. 4.184 cal
   3. 1 kcal
   4. 1000 kcal
2. For most chemical reactions
   1. Δ*E* is much larger than Δ*H*.
   2. the difference between Δ*H* and Δ*E* is very small.
   3. Δ*H* is equal to Δ*E*.
   4. Δ*H* is much larger than Δ*E*.
3. 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.
4. For which should the standard heat of formation Δ*Hof*, be zero at 25oC?
   1. O2 (g)
   2. O (g)
   3. O3 (g)
   4. All of the above
5. The values of Δ*Hºf* for the three states of benzene are approximately -22 kcal/mol, -11 kcal/mol, and 20 kcal/mol. Which is the value for solid benzene?
   1. 20 kcal/mol
   2. −11 kcal/mol
   3. −22 kcal/mol
   4. cannot be determined without additional information
6. Which equation represents the reaction whose Δ*H*, represents the standard enthalpy of formation of CHCl3(*l*) at 25oC? (*i.e.*, for which is Δ*H* = Δ*Hof* of CHCl3)
   1. CHCl3(*l*) 🡪 C(*s*) + H(*g*) + 3 Cl(*g*)
   2. C(*s*) + H(*g*) + 3 Cl(*g*) 🡪 CHCl3(*l*)
   3. 2 C(*s*) + H2(*g*) + 3 Cl2(*g*) 🡪 2 CHCl3(*l*)
   4. C(*s*) + 1/2 H2(*g*) + 3/2 Cl2(*g*) 🡪 CHCl3(*l*)
7. 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.
   5. None of the above’
8. You are given two flasks of equal volume. One contains H2 at 0oC and 1 atm while the other contains CO2 at 0oC and 2 atm. Which of the following quantities will be the same for both flasks?
   1. average molecular speed
   2. average molecular kinetic energy
   3. number of molecules present
   4. density
   5. both a and d are correct
9. Which one of the following gases will have the **highest** rate of effusion?
   1. NO2
   2. NO3
   3. N2O4
   4. N2O
10. The process of forming a bond between two elements
    1. depends on each elements heat of formation
    2. is generally an endothermic process
    3. occurs only under laboratory conditions
    4. has a negative heat of reaction
    5. has a positive heat of reaction
11. A quantized variable
    1. is extremely small.
    2. can be continuously varied.
    3. has units of joules
    4. consists of photons.
    5. can only assume certain values.
12. The intensity of a beam of light is related to its
    1. relative number of photons.
    2. frequency.
    3. wavelength.
    4. speed.
    5. none of the above

Part II -- Problems (79 points)

1. (4 points) Carry out the following conversions
   1. 837 torr to kPa
   2. 0.497 atm to mm Hg
2. (5 points) A sample of argon gas has a volume of 3.48 L and a pressure of 0.834 atm at 25.0oC. If the pressure increases to 6.06 atm and the temperature increases to 110.0oC, what is the final volume?
3. (5 points) Use kinetic molecular theory to explain the change in pressure that results from warming a sample of gas.

As the gas warms, the speed of the molecules increases thus hitting the surfaces harder and increasing pressure.

1. (5 points) What is the pressure in millimeter of mercury inside a container of gas connected to a mercury-filled open-end manometer when the level in the arm connected to the container is 6.8 cm lower than the level in the arm open to the atmosphere and the atmospheric pressure reading outside the apparatus is 754.3 mm Hg?



Pressure gas =pressure atmosphere + pressure Hg

Pressure gas = 68 mm Hg + 754.3 mm Hg

Pressure gas = 822 mm Hg

1. (12 points) A hydrocarbon has a density of 4.17 g/L at a temperature of 25oC and a pressure of 1.50 atm.
   1. Determine the molar mass of the hydrocarbon

Molar mass = \_\_\_68.0 g/mol\_\_\_\_\_\_\_\_\_\_\_

* 1. If there is a leak in the tank containing the hydrocarbon, how long will it take for 1 mol of the hydrocarbon to effuse. A sample of argon gas effuses from the same tank at a rate of 1 mol/6.3 days.

1. (5 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 faster than the aluminum because less energy is required to change its temperature.

1. (6 points) Given the reaction

3 Fe2O3(s) + CO(g) 🡪 2 Fe3O4(s) + CO2(g) H = -46 kJ

determine the H for the following reactions

Fe2O3(s) + 1/3 CO(g) 🡪 2/3 Fe3O4(s) + 1/3 CO2(g)

4 Fe3O4(s) + 2 CO2(g) 🡪 6 Fe2O3(s) + 2 CO(g)

1. (9 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

How much heat is produced by a bombardier beetle that produces 15.0 mg of quinone?

1. (16 points) A sample of an unknown metal was reacted with 150.0 g of hydrochloric acid in a calorimeter.
   1. If a 8.664 g sample of the metal caused the temperature of the calorimeter and its contents to rise from 15.4oC to 43.7oC, calculate the heat of reaction in kJ/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 5.60 L container at 30.0oC and 783 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) The standard enthalpy of combustion of cyclo-octane (C8H16) is −1186.0 kJ/mol. The products of this combustion are liquid water and carbon dioxide gas. Calculate the standard enthalpy of formation of liquid cyclo-octane

C8H16(g) + 12 O2(g) ⎯→ 8 CO2(g) + 8 H2O(l)

Hc, (C8H16, g) = 8(Hf, CO2, g) + 8 (Hf, H2O, l)- 1 (Hf, C8H16) – 12(Hf, O2, g)

-1186.0 kJ = 8(-393.5 kJ) + 8 (-285.8 kJ) - 1 (Hf, C8H16) – 12(0 kJ)

-1186.0 kJ = -3148.0 kJ + -2286.4 kJ - (Hf, C8H16) -0 kJ

-1186.0 kJ = -5434.4 kJ - (Hf, C8H16)

- (Hf, C8H16) = + 4248.4 kJ

(Hf, C8H16)= -4248.4 kJ/mol

1. (9 points) The blue color of the sky results from the scattering of sunlight by air molecules. The blue light has a frequency of about 7.5 x 1014 Hz.
   1. Calculate the wavelength, in nm, associated with this radiation.
   2. Calculate the energy, in J, of a single photon associated with this frequency.
   3. The retina of a human eye can detect light when radiant energy incident on it is at least 4.0 x 10-17 J. How many photons of “sky blue” light does this correspond to?
2. (5 points) The ionization energy of manganese is 717 kJ/mol. Calculate the wavelength of light that will just ionize an atom of manganese.