Exam 2

# Part 1: Multiple Choice (2 points each)

## Directions: Please circle the *best* answer for each of the following questions.

1. Define vapor pressure.
	1. The partial pressure of water in a liquid mixture.
	2. The condensation of water.
	3. Water dissolved in a liquid.
	4. The partial pressure of water in a gaseous mixture.
	5. Water molecules.
2. Which statement is true about kinetic molecular theory?
	1. A single particle does not move in a straight line.
	2. The size of the particle is large compared to the volume.
	3. The collisions of particles with one another is completely elastic.
	4. The average kinetic energy of a particle is not proportional to the temperature.
3. In Lhasa, Tibet, the elevation is 12,000 ft. The altimeter reading in an airplane is 19.00 in Hg or
	1. 9.33 mm Hg.
	2. 0.635 mm Hg
	3. 483 mm Hg.
	4. 1.57 mm Hg
	5. 23.14 mm Hg
4. Which of the following is true if ∆Esys = -100 J?
	1. The system is gaining 100 J, while the surroundings are losing 100 J.
	2. The system is losing 100 J, while the surroundings are gaining 100 J.
	3. Both the system and the surroundings are gaining 100 J.
	4. Both the system and the surroundings are losing 100 J.
	5. none of the above
5. Which of the following (with specific heat capacity provided) would show the largest temperature change upon gaining 200.0 J of heat?
	1. 50.0 g ethanol, cethanol = 2.42 J/g °C
	2. 50.0 g Zn, cZn = 0.39 J/g °/c
	3. 25.0 g sand, csand = 0.84 J/g °C
	4. 25.0 g Au, cAu = 0.128 J/g °/c
	5. 25.0 g Ag, cAg = 0.235 J/g °C
6. A bomb calorimeter measures
	1. ∆H for combustion solutions.
	2. ∆E for combustion reactions.
	3. ∆H for oxidation solutions.
	4. ∆T for oxidation solutions.
	5. ∆E for reduction reactions.
7. When a wave encounters an obstacle or a slit that is comparable in size to its wavelength, it bends around it. This characteristic is called
	1. destructive interference.
	2. diffraction.
	3. constructive interference.
	4. effusion.
	5. amplitude.
8. If two electrons in the same atom have the same value of l, they are
	1. in the same sublevel, but not necessarily the same level.
	2. in the same level, but a different sublevel.
	3. in the same orbital.
	4. in different levels and in different shaped orbitals.
	5. none of the above
9. Rank the types of electromagnetic radiation in order of increasing wavelength.
	1. x-rays < microwaves < visible light
	2. microwaves < x-rays < visible light
	3. visible light < x-rays < microwaves
	4. x-rays < visible light < microwaves
	5. microwaves < visible light < x-rays

1. The best rule for disposal of waste from a chemistry lab is
	1. down the sink unless instructed otherwise.
	2. into trash cans unless instructed otherwise.
	3. into chemical waste receptacles unless instructed otherwise.
	4. both a and b
	5. all of the above

# Part 2: Short Answer

## Directions: Answer each of the following questions. Be sure to use complete sentences where appropriate. For full credit be sure to show all of your work.

1. Consider a container of gas under a particular P, V, T set of conditions. Describe how the pressure would change if the volume were doubled while the absolute temperature was increasing by a factor of two (3 points).

The pressure would stay constant. The doubling of the volume would, by itself, decrease the pressure by a factor of 2. However, the temperature is also increasing by a factor of 2. These two changing variables will cancel one another.

1. Before the development of reliable batteries, miners’ lamps burned acetylene produced by the reaction of calcium carbide with water (10 points):

CaC2 (s) + H2O (l) → C2H2 (g) + CaO (s)

A lamp uses 1.00 L of acetylene, C2H2, per hour at 1.00 atm pressure and 18 °C.

* 1. How many moles of acetylene are used per hour?

$$PV=nRT⇒n=\frac{PV}{RT}$$

$$n=\frac{\left(1.00 atm\right)\left(1.00 L\right)}{\left(0.08206\frac{L atm}{mol K}\right)\left(18+273\right)}$$

$$n=\frac{(1.00 atm)(1.00 L)}{\left(0.08206\frac{L atm}{mol K}\right)(291 K)}=0.041876994 mol ≈0.0419 \frac{mol}{hour}$$

* 1. How many grams of calcium carbide must be in the lamp for a four hour shift?
		1. $hour×0.0419 \frac{mol C\_{2}H\_{2}}{hour}×\frac{1 mol CaC\_{2}}{1 mol C\_{2}H\_{2} }×\frac{64.100 g CaC\_{2}}{1 mol CaC\_{2}}=10.7 g CaC\_{2}$
1. What is the final pressure of 1.00 mol of ammonia gas, initially at 1.00 atm if the volume is gradually decreased from 78.0 mL to 39.0 mL at constant temperature (6 points)?

$$PV=nRT⇒PV=constant⇒P\_{1}V\_{1}=P\_{2}V\_{2}⇒P\_{2}=P\_{1}\frac{V\_{1}}{V\_{2}}$$

$$P\_{2}=\left(1.00 atm\right)\left(\frac{78.0 mL}{39.0 mL}\right)=2.00 atm $$

1. Why are the standard heats of formation for elements in their most stable form assigned a value of “0” (3 points)?

We can't measure absolute enthalpy, but we can measure changes in enthalpy. Assigning all elements in their most stable form a value of "0" gives us a starting point from which to measure all other enthalpy changes.

1. For each of the following define a system and its surroundings, and give the direction of energy transfer between the system and surroundings (8 points).
	1. Methane burns in a gas furnace in your home.

System: reaction between methane and oxygen.

Surroundings: the furnace and the rest of the universe.

Energy is transferred as heat from the system to the surroundings.

* 1. Water drops, sitting on your skin after a swim, evaporate.

System: water drop

Surroundings: skin and the rest of the universe.

Energy is transferred as heat from the surroundings to the system.

* 1. Water, at 25 °C, is placed in the freezing compartment of a refrigerator, where is cools and eventually solidifies.

System: water

Surroundings: freezer and the rest of the universe

Energy is transferred as heat from the system to the surroundings.

* 1. Aluminum and Fe2O3 (s) are mixed in a flask sitting on a laboratory bench. A reaction occurs, and a large quantity of energy is evolved as heat.

System: reaction of aluminum and iron(III) oxide

Surroundings: flask, laboratory bench, and rest of the universe

Energy is transferred as heat from the system to the surroundings.

1. Two solutions, initially at 24.60 °C, are mixed in a coffee cup calorimeter. When a 100.0 mL volume of 0.100 M AgNO3 solution is mixed with a 100.0 mL sample of 0.200 M NaCl solution, the temperature in the calorimeter rises to 25.30 °C (10 points).
	1. Write the balanced chemical reaction.

NaCl (aq) + AgNO3 (aq) → AgCl (s) + NaNO3 (aq)

* 1. Determine the ∆H°rxn for the double displacement reaction. Assume that the density and heat capacity of the solution is the same as that of water (1.00 g/mL and 4.184 J/g °C).

$$q=mc∆T=(200.0 mL)\left(1.00\frac{g}{mL}\right)\left(4.184\frac{J}{g ℃}\right)(25.30 ℃-24.60 ℃)$$

$$q=\left(200.0 g\right)\left(4.184\frac{J}{g ℃}\right)\left(0.70 ℃\right)=585.76 J released≈590 J released$$

1. Isooctane (2,2,4-trimethylpentane), one of the many hydrocarbons that makes up gasoline, burns in air to give water and carbon dioxide (8 points):

2 C8H18 (l) + 25 O2 (g) → 16 CO2 (g) + 18 H2O (l) ∆rH° = -10,922 kJ/mol-rxn

* 1. Is the reaction exothermic or endothermic? \_\_\_\_\_\_exothermic\_\_\_\_\_\_\_\_
	2. What is the enthalphy change if you burn 1.00 L of isooctane (d = 0.69 g/mL)?

$$1.00 L×\frac{1000 mL}{1 L}×\frac{0.69 g C\_{8}H\_{18}}{1 mL}×\frac{1 mol C\_{8}H\_{18}}{114.232 g C\_{8}H\_{18}}×\frac{-10,922 kJ}{2 mol C\_{8}H\_{18}}=-3.3×10^{4} kJ$$

1. What is the photoelectric effect (3 points)?

Many metals emit electrons when light of high enough energy is shone on them. This observation brought the classical view of light into question.

1. How many orbitals are contained in the n = 2 level? Give the l and ml values of each of them (5 points).

Four: the 2s and three 2p orbitals.

|  |  |  |  |
| --- | --- | --- | --- |
|  | n | l | ml |
| 2s | 2 | 0 | 0 |
| 2p | 2 | 1 | -1 |
| 2 | 1 | 0 |
| 2 | 1 | +1 |

1. Kinetic molecular theory tells us that helium atoms at 500 K are in constant motion.
	1. Calculate the root mean square speed of helium atoms at 500 K (10 points).

$$u\_{rms}=\sqrt{\frac{3RT}{MM}}=\sqrt{\frac{3\left(8.3145\frac{J}{mol K}\right)(500 K)×\frac{1 kg \frac{m^{2}}{s^{2}}}{1 J}}{4.003\frac{g}{mol}×\frac{1 kg}{1000 g}}}=1.77×10^{3}\frac{m}{s}$$

* 1. What is the de Broglie wavelength of a helium atom at 500 K?

$$λ=\frac{h}{mu}$$

$$λ=\frac{6.626 ×10^{-34} J s}{\left(4.003\frac{g}{mol}×\frac{1 mol }{6.022×10^{23} atoms}×\frac{1 kg}{1000 g}\right)\left(1.77×10^{3}\frac{m}{s}\right)}×\frac{1 kg\frac{m^{2}}{s^{2}}}{1 J}×\frac{1 nm}{10^{-9} m}$$

$$λ=0.0563 nm$$

1. The energies of the photons emitted by one-electron atoms and ions fit the equation:

$$E=\left(2.178×10^{-18 }J\right)Z^{2}\left(\frac{1}{n\_{i}^{2}}-\frac{1}{n\_{f}^{2}}\right)$$

where Z is the atomic number, nf and ni are positive integers, and nf > n­i (2 points).

* 1. As the value of Z increases, does the wavelength of the photons associated with the transition from n =2 to n =1 increase or decrease?

$$E=\frac{hc}{λ} $$

decrease

* 1. Can the wavelength associated with the transition from n = 2 to n =1 ever be observed in the visible region of the spectrum?

No

1. The most prominent line the emission spectrum of aluminum is at 396.15 nm (c = 2.99792458 × 108 m/s, h = 6.6260696 × 10-34 J s, NA = 6.02214129 ×1023/mol) (12 points).
	1. What is the frequency of this line?

$$ν=\frac{c}{λ}=\frac{2.99792458×10^{8} \frac{m}{s}}{396.15×10^{-9} m}=7.567650082 ×10^{14}\frac{1}{s}≈7.5677×10^{14}\frac{1}{s}$$

* 1. What is the energy of one photon with this wavelength?

$$E=\frac{nhc}{λ}$$

$$E=\frac{(1)\left(6.6260696×10^{-34} J s\right)\left(2.99792458×10^{8} \frac{m}{s}\right)}{396.15×10^{-9} m}=5.0143×10^{-19}\frac{J}{photon}$$

* 1. Of one mol of these photons?

$$5.0143×10^{-19}\frac{J}{photon}×\frac{6.02214129×10^{23} photons}{1 mol photons}×\frac{1 kJ}{1000 J}=301.97\frac{kJ}{mol}$$