Exam 2

# Part 1: Multiple Choice (2 points each)

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

1. \_\_\_\_\_\_ gas particle travels the fastest.
2. Ne
3. O2
4. CO
5. H2
6. N2
7. Given three cylinders containing oxygen gas at the same volume and pressure: cylinder A is at -20 °C, cylinder B is at -15 °F, cylinder C is at 260 K. Which cylinder contains the largest mass of oxygen gas?
8. cylinder A
9. cylinder B
10. cylinder C
11. cylinder A & B
12. all contain the same mass
13. Which of the following samples will have the lowest pressure if they are all at the same temperature?
14. 15 g F2
15. 15 g Kr
16. 15 g Ne
17. 15 g CO2
18. all of the above
19. Which of the following is true if ∆Esystem = -95 J?
20. Both the system and the surroundings are losing 95 J.
21. The system is gaining 95 J, while the surroundings are losing 95 J.
22. The system is losing 95 J, while the surrounds are gaining 95 J.
23. Both the system and the surroundings are gaining 95 J.
24. none of the above
25. Identify what a bomb calorimeter measures.
26. measures ∆E for combustion reactions
27. measures ∆H for oxidation solutions
28. measures ∆T for hydrolysis solutions
29. measures ∆H for aqueous solutions
30. measures ∆E for reduction solutions
31. Which of the following statements is true?
32. State functions do not depend on the path taken to arrive at a particular state.
33. ∆Hrxn can be determined using constant pressure calorimetry.
34. ∆Erxn can be determined using constant volume calorimetry.
35. Energy is neither created nor destroyed, excluding nuclear reactions.
36. all of the above
37. The principle quantum numbers have the designation
38. H, He, Li…
39. 1, 2, 3…
40. k, m, s…
41. s, p, d…
42. α, β, γ…
43. all contain the same mass
44. Which of the following statements about the frequency of a particle is true?
45. Heavy, fast-moving objects have lower frequencies than those of lighter, faster-moving objects.
46. Only very light particles can have high frequencies.
47. Double the mass of an object and halving its speed result in no change in its frequency.
48. all of the above
49. none of the above
50. How many quantum numbers are needed to identify an orbital?
51. 0
52. 1
53. 2
54. 3
55. 4
56. Which of the following is permitted in lab?
	1. Eating
	2. Drinking
	3. Smoking
	4. Close-toed shoes
	5. Gum chewing

# 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. Can the partial pressure of one component of a gas be measured directly (2 points)?

No

1. Amontons’ Law, named in honor of French physicist Guillaume Amonoton, states that as the absolute temperature of a fixed amount of gas increases, the pressure increases as long as the volume and quantity of gas remain constant (8 points).
	1. Write Amontons’ law for a changing system.

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

* 1. The air pressure in the tires of an automobile is adjusted to 28 psi at a gas station in San Diego, CA, where the air temperature is 68 °F (20 °C). The air in the tires is at the same temperature as the atmosphere. The automobile is then driven east along highway 8 into the hot desert. Along the way, the temperature of the tires reaches 140 °F (60 °C). What is the pressure in the tires?

P1 = 28 psi

T1 = 20 °C + 273 = 293 K

T2 = 60 °C + 273 = 333 K

P2 = ?

$$\frac{P\_{1}}{T\_{1}}=\frac{P\_{2}}{T\_{2}}⇒P\_{2}=\frac{P\_{1}T\_{2}}{T\_{1}}=\frac{\left(28 psi\right)\left(333 K\right)}{\left(293 K\right)}=31.8225256 psi=32 psi$$

1. Radon is a hazardous because it is easily inhaled and it emits α particles when it undergoes radioactive decay (8 points).
2. Calculate the density of radon at 298 K and 1 atm of pressure.

$$PV=nRT;MM=\frac{m}{n}; D=\frac{m}{V}⇒D=\frac{P\left(MM\right)}{RT}$$

$$D=\frac{\left(1 atm\right)\left(\frac{222g}{mol}\right)}{\left(0.08206\frac{L atm}{mol K}\right)(298 K)}=9.08\frac{g}{L}$$

1. Are radon concentrations likely to be greater in the basement or on the top floor of a building?

Basement, the density of radon is much greater than air at sea level at 15 °C is approximately 1.225 g/L.

1. Scuba divers who descend more than 130 feet below the surface may breathe a gas mixture called Trimix, which is 11.7% He, 56.2% N2, and 32.1% O2 by mass. Calculate the mole fraction of oxygen gas in the mixture (7 points).

$$11.7\% He=11.7 g He×\frac{1 mol He}{4.003 g He}=2.92 mol He$$

$$32.1\% O\_{2}=32.1 g O\_{2}×\frac{1 mol O\_{2}}{31.998 g O\_{2}}=1.00 mol O\_{2}$$

$$56.2\% N\_{2}=56.2 g N\_{2}×\frac{1 mol N\_{2}}{28.014 g N\_{2}}=2.01 mol N\_{2}$$

$$χ\_{O\_{2}}=\frac{n\_{O\_{2}}}{n\_{total}}=\frac{1.00 mol}{(2.92 mol+1.00 mol+2.01 mol)}=\frac{1.00 mol}{5.93 mol}=0.169$$

1. Calculate the enthalpy of formation of SO2 (g) from the standard enthalpy changes of the following reactions (5 points):

2 SO2 (g) + O2 (g) → 2 SO3 (g) ∆Hrxn° = -196 kJ

¼ S8 (s) + 3 O2 (g) → 2 SO3 (g) ∆Hrxn° = -790 kJ

1/8 S8 (s) + O2 (g) → SO2 (g) ∆Hrxn° = ?

(¼ S8 (s) + 3 O2 (g) → 2 SO3 (g) ∆Hrxn° = -790 kJ) x ½

(2 SO3 (g) → 2 SO2 (g) + O2 (g) ∆Hrxn° = 196 kJ) x ½

1/8 S (g) + 3/2 O2 (g) + SO3 (g) → SO3 (g) + SO2 (g) + ½ O2 (g) ∆Hrxn° = -297 kJ

1/8 S (g) + O2 (g) → SO2 (g) ∆Hrxn° = -297 kJ

1. If a bottle of nail polish remover contains 178 mL of acetone, how much heat would be released by its complete combustion? The density of acetone in 0.788 g/mL (5 points).

C3H6O (l) + 4 O2 (g) → 3 CO2 (g) + 3 H2O (g) ∆H°rxn = -1790 kJ

$178 mL×\frac{0.788 g C\_{3}H\_{6}O}{1 mL}×\frac{1 mol C\_{3}H\_{6}O}{58.078 g C\_{3}H\_{6}O}×\frac{1790 kJ}{1 mol C\_{3}H\_{6}O}=4.32 ×10^{3} kJ released$

1. The reaction of nitrogen gas with hydrogen gas to make ammonia gas has ∆H° = -92.2 kJ. What is the value of ∆E (in kilojoules) if the reaction is carried out at a constant pressure of 40.0 atm and the volume change is -1.12 L (5 points)?

$$∆E=∆H-P∆V$$

$$∆E=-92.2 kJ-\left(40.0 atm\right)\left(-1.12 L\right)\left(101.325\frac{J}{L atm}\right)\left(\frac{1 kJ}{1000 J}\right)$$

$$∆E=-92.2 kJ-\left(-4.52 kJ\right)$$

$$∆E= -87.7 kJ$$

1. An ice cube of mass 9.0 g at temperature 0 °C is added to a cup of coffee, whose temperature is 90 °C and which contains 110 g of liquid. Assume the specific heat capacity of coffee is the same as that of water (4.184 J/g °C). The heat of fusion of ice (the heat associated with ice melting) is 6.0 kJ/mol. Find the temperature of the coffee after the ice melts (10 points).

$$q\_{in}=-q\_{out}$$

$$q\_{ice}=-q\_{coffee}$$

$$m\_{ice}∆H\_{ice}+m\_{ice}c\_{ice}∆T\_{ice}=-m\_{coffee}c\_{coffee}∆T\_{coffee}$$

$$m\_{ice}∆H\_{ice}+m\_{ice}c\_{ice}(T\_{f}-T\_{i ice})=-m\_{coffee}c\_{coffee}(T\_{f}-T\_{i coffee})$$

$$\left(9.0 g\right)\left(6.0\frac{kJ}{mol}\right)×\frac{1000 J}{1 kJ}×\frac{1 mol H\_{2}O}{18.016 g H\_{2}O }+\left(9.0g\right)\left(4.184\frac{J}{g ℃}\right)\left(T\_{f}-0℃\right)=-(110 g)(4.184\frac{J}{g℃})(T\_{f}-90℃)$$

$$3.0×10^{3}J+38\frac{J}{℃}\left(T\_{f}\right)=-460T\_{f}+4.1×10^{4}J$$

$$498\frac{J}{℃}\left(T\_{f}\right)=3.8×10^{4}J$$

$$T\_{f}=77 ℃$$

1. Answer the following questions about quantum numbers (10 points):
	1. When n = 4, what are the possible values of ℓ? \_\_\_\_n = 0, 1, 2, 3
	2. When ℓ is 2, what are the possible values of mℓ? \_\_\_\_ mℓ = -2, -1, 0, 1, 2
	3. For a 5s orbital, what are the possible values of n, ℓ, and mℓ?

n = 5, ℓ = 0, and mℓ = 0

* 1. For a 4f orbital, what are the possible values of n, ℓ, and mℓ?

n = 4, ℓ = 3, and mℓ = -3, -2, -1, 0, 1, 2, 3

1. Why are the various forms of radiant energy called electromagnetic radiation (2 points)?

All of the forms of light have perpendicularly oscillating electric and magnetic fields that travel together through space.

1. Answer the following questions about the de Broglie relation $λ=\frac{h}{mv}$ (8 points):
2. Explain how the relation links the properties of a particle to those of a wave.

This equation states that (1) any moving particle will have wavelike properties because a wavelength can be calculated using the equation and (2) the wavelength of the particle is inversely related to its momentum (mass multiplied by velocity).

1. Would the density or shape of an object have an effect on its de Broglie wavelength?

No

1. Calculate the wavelength, in nm, of a muon (a subatomic particle with a mass of 1.884 x 10-25 g) traveling at 325 m/s.

$$λ=\frac{h}{mv}=\frac{6.626×10^{-34} J s}{(1.884 ×10^{-25} g)(325\frac{m}{s})}×\frac{1 kg\frac{m^{2}}{s^{2}}}{1 J}×\frac{1000 g}{1 kg}=1.08×10^{-8} m=10.8 nm$$

1. One of the transitions in the visible hydrogen spectrum corresponds to ni = 2 and nf = 3 (10 points)?
	1. What is the wavelength of the line?

 $\frac{1}{λ}=R\_{H}\left(\frac{1}{n\_{i}^{2}}-\frac{1}{n\_{f}^{2}}\right)=1.097×10^{-2} nm^{-1}\left(\frac{1}{2^{2}}-\frac{1}{3^{2}}\right)=1.524×10^{-3} nm^{-1}$

$$λ=\frac{1}{1.524 ×10^{-3} nm^{-1}}=656.4 nm$$

 Or

Using the answer from c: $E=\frac{hc}{λ}⇒λ=\frac{hc}{E}=\frac{(6.626×10^{-34} J s)(3.00 ×10^{8}\frac{m}{s})}{3.03×10^{-19}J}×\frac{10^{9}nm}{1 m}=657 nm$

* 1. What color does that transition correspond to? \_\_\_\_\_red\_\_\_\_\_
	2. What is the energy of the transition?

$$E=\frac{hc}{λ}=\frac{(6.626×10^{-34} J s)(3.00 ×10^{8}\frac{m}{s})}{656.4 ×10^{-9}m}=3.03×10^{-19} J$$

 Or

$$∆E=\left(-2.18×10^{-18}J\right)\left(\frac{1}{n\_{f}^{2}}-\frac{1}{n\_{i}^{2}}\right)=\left(-2.18×10^{-18}J\right)\left(\frac{1}{3^{2}}-\frac{1}{2^{2}}\right)=3.03×10^{-19}J$$