Name: KEY Section: _____

CHM 151 Exam 4: Chapters 9 and 8
You must show all work to receive credit. Clearly mark your final answer!

1. Matching: Indicate how the following changes made to a system (shown on the left) will affect the pressure of the system (letter options on the right). The system is initially filled with oxygen molecules (32g/mol). For each change, assume variables not mentioned are held constant. Note: Answer choices may be used more than once!

10 (2 pts each)

Changes to system:
- d Volume is doubled
- e Temperature changes from 200°C to 400°C
- c Temperature is halved and volume is halved
- c O_2 molecules are replaced with SO_2 (64g/mol)
- d Half of the molecules effuse from the container

Pressure changes:
a. Pressure is doubled
b. Pressure is quadrupled
c. No change in pressure
d. Pressure lowers
e. None of the above

2. What must happen if you cool a gas? Explain, as described in lecture, what other things might happen and describe the conditions under which they will happen.

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If you cool a gas, the average speed of the particles must be lower (less kinetic energy). (4)

If the temperature falls below the boiling point, the gas will condense into a liquid. (2)

If the container is rigid, P will be lower (particles hit walls less often + less hard) (2)

If the container is flexible, V will decrease. ($P_{int} = P_{ext}$) (2)

3. A sample of gas (28g/mol) initially at 1.50 L was cooled from 400°C at constant pressure until the volume of the gas was 0.75 L. After the cooling, the gas temperature is _____ °C. Which law is illustrated by this example? Show your work.

10

400°C ← not very precise.
+ 273
673 K (2)

$\frac{V_1}{T_1} = \frac{V_2}{T_2}$ (2)

$\frac{1.50\ L}{673\ K} = \frac{0.75\ L}{T_2}$

$673\ K(0.75\ L) = 1.50\ L(T_2)$

$\frac{673\ K(0.75\ L)}{1.50\ L} = T_2$

(2) $336\ K = T_2$

336 K
− 273
63 °C (1)

(3) V, T = Charles' Law.

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4. A sample of metal that weighs 2.56g is heated to 65°C and placed in a 12.5g sample of water at 21.65°C. If the final temperature of the water is 22.1°C, what is the specific heat capacity of the metal?

(4) $-q_{metal} = q_{H_2O}$

(2) $-mc(T_F - T_i)_{metal} = mc(T_F - T_i)_{H_2O}$

8 $-2.56\,g\,(c)(22.1°C - 65°C) = +12.5\,g\,(4.184\,\frac{J}{g°C})(22.1°C - 21.65°C)$

$-2.56\,g\,c\,(42.9°C) = 52.3\,\frac{J}{°C}(0.45°C)$

$109.8\,g°C\,(c) = 23.5\,J$

$c = \frac{23.5\,J}{109.8\,g°C} = 0.214\,\frac{J}{g°C}$ ← could be Sn

(2)

5. A closed 2.50 L container holds CH_4 and H_2 gases. The partial pressure of hydrogen is measured to be 675 torr at 22.5°C.

a) How many moles of hydrogen are present?

(2) $675\ torr \times \frac{1\ atm}{760\ torr} = 0.888\ atm$

$22.5°C + 273.15 = 295.65\,K$ (2)

8

$PV = nRT$ (2)

$n = \frac{PV}{RT} = \frac{0.888\ atm\,(2.50\,L)}{(0.08206\,\frac{L\,atm}{mol\,K})(295.65\,K)} = 0.0914\ mol\ H_2$ (2)

b) If the mole fraction of hydrogen is 0.842, what is the total pressure of the gas sample?

(2) $\chi_{H_2} P_{TOT} = P_{H_2}$

4 $0.842\,(P_{TOT}) = 0.888\ atm$

$P_{TOT} = \frac{0.888\ atm}{0.842} = 1.05\ atm$ (2)

(or 802 torr)

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6. In a balloon with a small pinhole leak, which gas will have the highest concentration outside the balloon after one hour if all gases were at equal concentrations initially? Show your work.

(8)

a. neon 20 g/mol

b. sulfur dioxide 64 g/mol

c. fluorine 38 g/mol

d. butane (C_4H_{10}) 58 g/mol

fastest = smallest

escapes first

if 19 g/mol, 4 pts. for picking the lightest,

7. Write the chemical equation that corresponds to the heat of formation for each substance. Indicate whether the value of the heat of formation is a positive number, negative number or zero.

3 a) $I_2(s)$ $I_{2(s)} \longrightarrow I_{2(s)}$ $\Delta H_f = 0$

3 b) $CO_2(g)$ $C_{(s)} + O_{2(g)} \longrightarrow CO_{2(g)}$ $\Delta H = \ominus$ combustion

3 c) $CaCO_3(s)$ $Ca_{(s)} + C_{(s)} + O_{2(g)} \rightarrow CaCO_{3(s)}$ $\Delta H = \ominus$

3 d) $Br_2(g)$ $Br_{2(g)} \longrightarrow Br_{2(g)}$ $\Delta H = \oplus$ boiling

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8a. Write the balanced equation (smallest whole number coefficients) for the combustion of magnesium.

(4) $2\,Mg(s) + O_2(g) \rightarrow 2\,MgO(s)$

b. If the heat of formation of magnesium oxide is -601.7 kJ, what is the enthalpy change for the reaction represented by the equation in part a?

$Mg + \frac{1}{2}O_2(g) \rightarrow MgO(s) \quad \Delta H = -601.7\,kJ$

(4) so forming 2 mol $MgO(s)$ $\Delta H = -1203.4\,kJ$

c. How much energy will be released if 2.5 mol of Mg is burned in the presence of excess oxygen gas?

(2) $2.5\,mol\,Mg \times \frac{-601.7\,kJ}{1\,mol} = -1504\,kJ$

(2) +1500 kJ of energy is released

9. A gas has been discovered by a chemist who believes its formula is C_3O_2. In order to confirm this, he determines its density. What should be the density of this gas at a pressure of 0.863 atm and a temperature of 296.7 K?

(8) $d = \frac{P\,MW}{RT} = \frac{0.863\,atm\,(68.03\,g/mol)}{0.08206\,\frac{L\,atm}{mol\,K}\,(296.7\,K)} = 2.41\,\frac{g}{L}$ (4)

(2) $C_3O_2 = 3 \times 12.011\,g/mol + 2 \times 15.999\,g/mol = 68.031\,g/mol$

10. Given the following information, calculate the enthalpy of combustion of acetylene, C_2H_2.

$2\,C_2H_2(g) + 5\,O_2(g) \rightarrow 4\,CO_2(g) + 2\,H_2O(l)$

ΔH_f° of $CO_2(g)$ = -393.5 kJ/mol

ΔH_f° of $H_2O(l)$ = -285.8 kJ/mol

ΔH_f° of $C_2H_2(g)$ = 227.4 kJ/mol

(2) $\Delta H_{rxn} = \Delta H_f(products) - \Delta H_f(reactants)$

(2) $\Delta H_{rxn} = 4(\Delta H_f(CO_2)) + 2(\Delta H_f(H_2O)) - 2\Delta H_f(C_2H_2) - 0$

(10) (4) $\Delta H_{rxn} = 4(-393.5\,kJ) + 2(-285.8\,kJ) - 2(227.4\,kJ)$

$= -1574\,kJ - 571.6\,kJ - 454.8\,kJ$

(2) $= -2600.4\,kJ$ $\quad -2.600 \times 10^3\,kJ$

(30)