CHM1045 Practice Test 3 v.1 - Answers

Name______________________________

Fall 2013 & 2011 (Ch. 5, 6, 7, & part 11)

Revised April 10, 2014

Given: Speed of light in a vacuum = 3.00×10^8 m/s

Planck's constant = 6.626×10^{-34} J•s

$$\Delta E = (-2.18 \times 10^{-18}\ \mathrm{J})\left(\frac{1}{n_{final}^2} - \frac{1}{n_{initial}^2}\right)$$

Part A. Multiple Choice – <u>Circle</u> the best answer, **FILL IN THE BLANK or ANSWER**.

1. The first law of thermodynamics is: (1 pt.)
   - A) Mass is neither created nor destroyed.
   - *B) Energy is neither created nor destroyed.
   - C) Pressure is constant.
   - D) Gases obey the gas laws.

2. Standard Temperature and Pressure (STP) for gases is ___________. (2 pts.)

   A) 25°C, 1 atm B) 0°C, 760 atm *C) 0°C, 760 Torr D) 1°C, 0 atm

3. If the temperature of a gas decreases, what will happen to the volume if all other variables are held constant? (2 pts.)

   a) increase *b) decrease c) stays the same

4. Question #3 above illustrates: (2 pts.)
   - *a) Charles' Law
   - b) Avogadro's Law
   - c) Boyle's Law
   - d) Graham's Law
   - e) Dalton's Law

5. What are the possible values of n and m_l for an electron in a 3d orbital? (2 pts.)
   - a) $n = 3$ and $m_l = 2$
   - b) $n = 3$ and $m_l = -1, 0, \text{or} +1$
   - c) $n = 2$ and $m_l = -2, -1, 0, +1, \text{or} +2$
   - *d) $n = 3$ and $m_l = -2, -1, 0, +1, \text{or} +2$
   - e) $n = 3$ and $m_l = -3, -2, -1, 0, +1, +2, \text{or} +3$

6. Which of the following set of quantum numbers are <u>not</u> allowed? (2 pts.)
   - a) n=2, l=1, m_l= −1,0,+1
   - b) n=3, l=2, m_l= −2, −1, 0, +1, +2
   - *c) n=3, l=3, m_l= −3, −2, −1, 0, +1, +2, or +3
   - d) n=3, l=1, m_l= −1,0,+1

7. Kinetic Energy is defined as:
   (2 pts.)

   = the energy of a moving object

8. The change of state from a gas to a solid is called ___deposition______________. (1 pt.)

9. The name of the quantum number n is ___the principal quantum number______________. (1 pt.)

10. Give a general description in words of the van der Waals equation (don't need to give the actual equation) and list at least one "thing" that this equation corrects for. (3 pts.)

    - Calculates P, V, n, or T of a real gas, includes constants a & b that must be measured in the lab for each gas.
    - Corrects for the volume of a gas molecule
    - Corrects for attractions between molecules

11. The temperature of a 5.00 L container of N_2 gas is increased from 20ºC to 250ºC. If the volume is held constant, predict qualitatively how this change affects the following: (a) the average kinetic of the molecules; (b) the average speed of the molecules; (c) the total number of collisions of molecules with the walls per second; (d) the pressure in the container. (8 pts.)

(a) The average kinetic energy increases since the temperature increases (energy is being added).

(b) The average velocity of the molecules increase because kinetic energy (K.E.) increased and

K.E. = $(1/2)\, mv^2$, (mass doesn't change so velocity must)

(c) the total number of collisions of molecules with the walls increase per second because they are moving faster, so they hit walls more frequently

(d) the pressure in the container increases because pressure is created by collisions of molecules with the walls, if there are more collisions per sec then the pressure increases.

Part B. Calculations. **MUST SHOW ALL WORK**. Give answer to correct significant figures and units.

12. (a) Is the following reaction exothermic or endothermic? Circle one. (2 pts.)
(b) How much heat is absorbed or released when 7.55g of hydrogen are produced? (4 pts.)

$$2\ NH_3(s) \rightarrow N_2\ (g) + 3\ H_2\ (g) \qquad \Delta H = +92.38\ kJ$$

$$\Delta H = \frac{+92.38\ kJ}{3\ moles\ H_2} = \frac{+30.79\ kJ}{1\ mole\ H_2}$$

$$7.55\ g\left(\frac{1\ mole\ H_2}{2.01588\ g}\right) = 3.7\bar{4}5\ moles\ H_2$$

$$3.745\ moles\ H_2\left(\frac{+30.79\ kJ}{1\ mole\ H_2}\right) = +115\ kJ$$

OR:

$$7.55\ g\left(\frac{1\ mole\ H_2}{2.01588\ g}\right)\left(\frac{92.38\ kJ}{3\ mole\ H_2}\right) = +115\ kJ$$

13. We obtain uranium-235 and U-238 by fluorinating the uranium to form UF_6 (which is a gas) and then taking advantage of the different rates of effusion and diffusion for compounds containing the two isotopes. Calculate the ratio of effusion rates for $^{238}UF_6$ and $^{235}UF_6$. The atomic mass of U-235 is 235.054 amu and that of U-238 is 238.051 amu (6 pts.)

$$\frac{r_{238}}{r_{235}} = \sqrt{\frac{\text{mass of } ^{235}UF_6}{\text{mass of } ^{238}UF_6}} = \sqrt{\frac{349.0444\ g/mole}{352.0414\ g/mole}} = 0.995737$$

14. (a) Convert 738 mmHg into Torr.
(b) Convert 738 mmHg into atm.
(c) Convert 738 mmHg into in.Hg. Show work. (8 pts. total)

(a) $$738\ \text{mmHg}\left(\frac{1\ \text{Torr}}{1\ \text{mmHg}}\right) = 738\ \text{Torr}$$

(b) $$738\ \text{mmHg}\left(\frac{1\ \text{atm}}{760\ \text{mmHg}}\right) = 0.971\ \text{atm}$$

(c) $$738\ \text{mmHg}\left(\frac{1\ \text{m}}{1000\ \text{mm}}\right)\left(\frac{100\ \text{cm}}{1\ \text{m}}\right)\left(\frac{1\ \text{in.}}{2.54\ \text{cm}}\right) = 29.1\ \text{in. Hg}$$

15. Zinc metal reacts with hydrochloric acid according to the balanced equation:

$$Zn\ (s) + 2\ HCl\ (aq) \rightarrow ZnCl_2\ (aq) + H_2\ (g)$$

When 0.103 g of Zn (s) is combined with enough HCl to make 50.0 mL of solution in a coffee-cup calorimeter, all of the zinc reacts, raising the temperature of the solution from 22.5°C to 23.7°C. Find ΔH for this reaction as written. (Use 50.0 g as the mass of the solution and 4.18 J/g·°C as the specific heat.) (7 pts.)

$$q_{surr} = \left(\frac{4.18\ \text{J}}{\text{g}\cdot{}^\circ\text{C}}\right)(50.0\ \text{g})(23.7\ {}^\circ\text{C} - 22.5\ {}^\circ\text{C}) = 2\bar{5}0.8\ \text{J} \quad , \quad q_{rxn} = -250.8\ \text{J}$$

$$0.103\ \text{g Zn}\left(\frac{1\ \text{mole Zn}}{65.39\ \text{g}}\right) = 0.001575\ \text{mole}$$

$$\Delta H = \frac{q_{rxn}}{\#\ \text{of moles}} = \frac{-2\bar{5}0.8\ \text{J}}{0.001575\ \text{mole}}\left(\frac{1\ \text{kJ}}{1000\ \text{J}}\right) = -159.22 = \frac{-160\ \text{kJ}}{1\ \text{mole Zn}}$$

16. A 248 mL gas sample has a mass of 0.433 g at a pressure of 745 Torr and a temperature of 28°C. What is the molar mass of the gas? (6 pts.)

$$P = 745\ \text{Torr}\left(\frac{1\,\text{atm}}{760\,\text{Torr}}\right) = 0.98\bar{0}2631579\,\text{atm} \quad , \quad T = 28\ °C = 30\underline{1}.15\ K \quad , \quad V = 248\ mL = 0.248\ L$$

PV = nRT

$$n = \frac{PV}{RT} = \frac{(0.98\bar{0}2631579\,\text{atm})(0.248\,\text{L})}{\left(0.08206\,\frac{\text{L}\cdot\text{atm}}{\text{mole}\cdot\text{K}}\right)(30\bar{1}.15\,\text{K})} = 0.0098\bar{3}73921\,\text{mole}$$

$$\text{Molar mass} = \frac{\text{grams}}{\text{moles}} = \frac{0.433\,\text{g}}{0.0098373921\,\text{mole}} = 44.0\,\frac{\text{g}}{\text{mole}}$$

17. A local radio station broadcasts and an energy of 7.82 x 10^{-26} J. What is this frequency in MHz? Show work. (4 pts.)

$$E = h\nu, \quad \nu = \frac{E}{h} = \left(\frac{7.82x10^{-26}\ \text{J}}{6.626x10^{-34}\ \text{J}\cdot\text{s}}\right)\left(\frac{1\,\text{Hz}}{\text{s}^{-1}}\right)\left(\frac{1\,\text{MHz}}{1x10^{6}\ \text{Hz}}\right) = 118\,\text{MHz}$$

18. Green light has a wavelength of about 0.550 μm. What is the frequency in Hertz? (3 pts.)

$$\lambda = 0.550\ \mu\text{m}\left(\frac{1\,x\,10^{-6}\ \text{m}}{1\ \mu\text{m}}\right) = 5.50x10^{-7}\ \text{m}$$

$$\lambda\nu = c, \qquad \nu = \frac{c}{\lambda} = \left(\frac{3.00x10^{8}\ \text{m/s}}{5.50x10^{-7}\ \text{m}}\right) = 5.45x10^{14}\ \text{s}^{-1} = 5.45x10^{14}\ \text{Hz}$$

19. A gas mixture contains 1.45 g N_2 and 0.65 g O_2 in a 1.75 L container at 19°C. Calculate the partial pressure of each component in the gas mixture and calculate the total pressure. (7 pts.)

There are several ways to do this problem, all are shown below. T 19°C = $29\underline{2}.15$ K , V = 1.75 L

$$1.45\text{ g N}_2\left(\frac{1\text{ mole N}_2}{28.0134\text{ g}}\right) = 0.051\bar{7}60943\text{ mole}$$

$$0.65\text{ g O}_2\left(\frac{1\text{ mole O}_2}{31.9988\text{ g}}\right) = 0.02\bar{0}3132617\text{ mole}$$

n_{total} = $0.07\underline{2}0742047$ mole

$$P_{total} = \frac{n_{total}RT}{V} = \frac{(0.0720742047\text{ mole})\left(0.08206\,\frac{\text{L}\cdot\text{atm}}{\text{mole}\cdot\text{K}}\right)(29\bar{2}.15\text{ K})}{1.75\text{ L}} = 0.9873683771 = 0.99\text{ atm}$$

$$P_{N_2} = \frac{n_{N_2}RT}{V} = \frac{(0.051\bar{7}60943\text{ mole})\left(0.08206\,\frac{\text{L}\cdot\text{atm}}{\text{mole}\cdot\text{K}}\right)(29\bar{2}.15\text{ K})}{1.75\text{ L}} = 0.70\bar{9}0902836 = 0.709\text{ atm}$$

$$P_{O_2} = \frac{n_{O_2}RT}{V} = \frac{(0.02\bar{0}3132617\text{ mole})\left(0.08206\,\frac{\text{L}\cdot\text{atm}}{\text{mole}\cdot\text{K}}\right)(29\bar{2}.15\text{ K})}{1.75\text{ L}} = 0.2\bar{7}82780928 = 0.28\text{ atm}$$

$$P_{O_2} = P_{total} - P_{N_2} = 0.278278\text{ atm} = 0.28\text{ atm}$$

$$P_{O_2} = \left(\frac{n_{O_2}}{n_{total}}\right)P_{total} = \left(\frac{0.02\bar{0}313\text{ mole}}{0.07\bar{2}07\text{ mole}}\right)(0.987\text{ atm}) = 0.2\bar{7}8278\text{ atm} = 0.28\text{ atm}$$

$$P_{N_2} = \left(\frac{n_{N_2}}{n_{total}}\right)P_{total} = \left(\frac{0.051\bar{7}6\text{ mole}}{0.07\bar{2}07\text{ mole}}\right)(0.987\text{ atm}) = 0.70\bar{9}09\text{ atm} = 0.709\text{ atm}$$

20. How much energy is needed to heat 45.0 g of H_2O (s) from –25.0°C to 0.0°C? (4 pts.)

$$q = \left(\frac{2.092\ \text{J}}{\text{g}\cdot\text{K}}\right)(45.0\ \text{g})\left(0.0^\circ\text{C} - (-25.0^\circ\text{C})\right)\left(\frac{1\ \text{kJ}}{1000\ \text{J}}\right) = 2.35\ \text{kJ}$$

21. How much energy in kJ is needed to convert 115.0 g of H_2O from a liquid at 100ºC to a gas at 100ºC? (4 pts.) (see Given information on page 1)

$$115.0\ \text{g H}_2\text{O}\left(\frac{1\ \text{mole H}_2\text{O}}{18.01528\ \text{g}}\right)\left(\frac{40.67\ \text{kJ}}{1\ \text{mole H}_2\text{O}}\right) = 259.6\ \text{kJ}$$

22. CH_3OH can be synthesized by the reaction:

$$CO\ (g) + 2\ H_2\ (g) \rightarrow CH_3OH\ (g)$$

What volume of H_2 gas (in liters), at 85°C and 746 mmHg partial pressure of hydrogen gas, is required to synthesize 27.7 g of CH_3OH? MUST SHOW WORK. (7 pts.)

$$T = 85^\circ\text{C} = 35\underline{8}.15\ \text{K} \quad , \quad P = 746\ \text{mmHg}\left(\frac{1\ \text{atm}}{760\ \text{mmHg}}\right) = 0.98\bar{1}5789474\ \text{atm}$$

$$27.7\ \text{g CH}_3\text{OH}\left(\frac{1\ \text{mole CH}_3\text{OH}}{32.04216\ \text{g}}\right)\left(\frac{2\ \text{mole H}_2}{1\ \text{mole CH}_3\text{OH}}\right) = 1.7\bar{2}8972079\ \text{mole H}_2$$

$$P_{H_2}V = n_{H_2}RT$$

$$V = \frac{n_{H_2}RT}{P_{H_2}} = \frac{(1.7\bar{2}897\ \text{mol})\left(0.08206\ \frac{\text{L}\cdot\text{atm}}{\text{mole}\cdot\text{K}}\right)(35\bar{8}.15\ \text{K})}{0.98\bar{1}5789\ \text{atm}} = 51.\bar{7}677 = 51.8\ \text{L}$$

23. The volume of helium gas in a balloon is 5.0 L at 788 Torr. What is the volume of the balloon at 465 Torr if the temperature is constant? (6 pts.)

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2} \quad , \quad T_1 = T_2 \quad , \quad \frac{P_1V_1}{\cancel{T_1}} = \frac{P_2V_2}{\cancel{T_2}} \; , \; P_1V_1 = P_2V_2$$

$$V_2 = \frac{P_1V_1}{P_2} = \frac{(788\,\text{Torr})(5.0\,\text{L})}{465\,\text{Torr}} = 8.473 = 8.5\,\text{L}$$

24. Use the change in enthalpy of formations to calculate ΔH of the following reaction. (7 pts.)

$$N_2O_4\,(g) \; + \; 4\,H_2(g) \;\rightarrow\; N_2\,(g) \; + \; 4\,H_2O\,(g)$$

The enthalpy of formations of H_2O (g) and N_2O_4 (g) are given on an attached table.

ΔH_{rxn} = [(1 mole)ΔH_f(N_2(g)) + (4 mole)ΔH_f(H_2O(g))] – [(1 mole)ΔH_f(N_2O_4(g)) + (4 mole)ΔH_f(H_2(g))]

= [0 + (4 mole)(–241.82 kJ)] – [+9.66 kJ + 0]

= [–967.28 kJ] – [+9.66 kJ] = –976.94 kJ

25. Calculate ΔH for the following reaction: (8 pts) **MUST SHOW ALL WORK!**

$5\ C\ (s) + 6\ H_2\ (g) \rightarrow C_5H_{12}\ (l)$

Using the enthalpies of reactions:

reverse: ~~$C_5H_{12}\ (l) + 8\ O_2\ (g) \rightarrow 5\ CO_2\ (g) + 6\ H_2O\ (g)$ ΔH = −3244.8 kJ~~

~~(5){$C\ (s) + O_2\ (g) \rightarrow CO_2\ (g)$} ΔH = {−393.5 kJ}(5)~~

~~(3){$2\ H_2\ (g) + O_2\ (g) \rightarrow 2\ H_2O\ (g)$} ΔH = {−483.5 kJ}(3)~~

$5\ CO_2\ (g) + 6\ H_2O\ (g) \rightarrow C_5H_{12}\ (l) + 8\ O_2\ (g)$ ΔH = +3244.8 kJ

$5\ C\ (s) + 5\ O_2\ (g) \rightarrow 5\ CO_2\ (g)$ ΔH = {−393.5 kJ}(5) = −1967.5 kJ

$6\ H_2\ (g) + 3\ O_2\ (g) \rightarrow 6\ H_2O\ (g)$ ΔH = {−483.5 kJ}(3) = −1450.5 kJ

~~$5\ CO_2\ (g)$~~ + ~~$6\ H_2O\ (g)$~~ + $5\ C\ (s)$ + ~~$5\ O_2\ (g)$~~ + $6\ H_2\ (g)$ + ~~$3\ O_2\ (g)$~~ →

→ $C_5H_{12}\ (l)$ + ~~$8\ O_2\ (g)$~~ + ~~$5\ CO_2\ (g)$~~ + ~~$6\ H_2O\ (g)$~~

$5\ C\ (s) + 6\ H_2\ (g) \rightarrow C_5H_{12}\ (l)$ ✓(exactly the reaction we wanted)

ΔH = (+3244.8 kJ) + (−1967.5 kJ) + (−1450.5 kJ) = −173.2 kJ

26. The oxygen gas formed in a chemical reaction is collected over water at 30.0ºC at a total pressure of 732 mmHg. What is the partial pressure of the oxygen gas collected in this way? If the total volume of gas collected is 722 mL, what mass of oxygen gas is collected? (8 pts.)

T = 30.0°C = 303.$\underline{1}$5 K

P_{total} = 732 mmHg

$$P_{H_2O} = 31.82\ \text{Torr}$$

$$P_{O_2} = P_{total} - P_{H_2O} = 732\ \text{Torr} - 31.82\ \text{Torr} = 70\bar{0}.18\ \text{Torr}\left(\frac{1\ \text{atm}}{760\ \text{Torr}}\right) = 0.92\bar{1}2897737\ \text{atm}$$

$$P_{O_2}V = n_{O_2}RT$$

$$n_{O_2} = \frac{P_{O_2}V}{RT} = \frac{(0.92\bar{1}289\ \text{atm})(0.722\ \text{L})}{\left(0.08206\ \frac{\text{L}\cdot\text{atm}}{\text{mole}\cdot\text{K}}\right)(303.\bar{1}5\ \text{K})} = 0.0267389421\ \text{mole}\ O_2\left(\frac{31.9988\ \text{g}}{1\ \text{mole}\ O_2}\right) = 0.856\ \text{g}\ O_2$$

Given for Test 3

Gas constant = 0.08206 L·atm/mole·K = 8.314 J/mole·K

1 cal = 4.184 J

Properties of Water

Density =	0.99987 g/mL at 0°C	Specific heat =	ice, 2.092 J/gK
	1.00000 g/mL at 4°C		water, 4.184 J/gK
	0.99707 g/mL at 25°C		steam, 1.841 J/gK
	0.95838 g/mL at 100°C		

Heat of fusion = 6.008 kJ/mol   Heat of vaporization = 40.67 kJ/mol

Properties of Ethanol (C_2H_5OH)

Melting point = –117.3°C   Boiling point = 78.5°C

Heat of fusion = 26.05 cal/g   Heat of vaporization = 9,673.9 cal/mol

Specific heat = liquid, 27.0 cal/mol
gas, 15.7 cal/mol

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compound	ΔH_f (kJ/mole)	compound	ΔH_f (kJ/mole)
CH_4(g)	−74.8	C_3H_8 (g)	−103.85
CO (g)	−110.5	C_4H_{10} (g)	−124.73
CO_2 (g)	−393.5	C_4H_{10} (l)	−147.6
H_2O (g)	−241.82		
H_2O (l)	−285.83		
NO(g)	+90.37		
NO_2(g)	+33.84		
N_2O(g)	+81.6		
N_2O_4(g)	+9.66		
C_2H_4 (g)	+52.30		
C_2H_6 (g)	−84.68		

Vapor pressue of water (Torr):

Vapor Pressure (torr)

T (°C)	P	*T* (°C)	P	*T* (°C)	P	*T* (°C)	P
0	4.58	21	18.65	35	42.2	92	567.0
5	6.54	22	19.83	40	55.3	94	610.9
10	9.21	23	21.07	45	71.9	96	657.6
12	10.52	24	22.38	50	92.5	98	707.3
14	11.99	25	23.76	55	118.0	100	760.0
16	13.63	26	25.21	60	149.4	102	815.9
17	14.53	27	26.74	65	187.5	104	875.1
18	15.48	28	28.35	70	233.7	106	937.9
19	16.48	29	30.04	80	355.1	108	1004.4
20	17.54	30	31.82	90	525.8	110	1074.6