Chem1B, Fall10, FH, Lec Exam1 Name KEY

Read questions carefully before answering. No outside paper is allowed. Use the reverse side of your answer paper as scratch. Use the periodic table and important constants charts provided.
(Total points = 38 + 52 + 16 = 106).

MULTIPLE CHOICE. Select the one alternative that best completes the statement or answers the question (2 pts each, if not mentioned otherwise).

$PV = nRT$
$P_1V_1 = P_2V_2$
$1\,atm(10\,L) = P_2(15\,L)$
$1\,atm\left(\frac{10\,L}{15\,L}\right) = P_2$
$0.67 = P_2$

1) A sample of a gas (5.0 mol) at 1.0 atm is expanded at constant temperature from 10 L to 15 L. The final pressure is 0.67 atm (4 pts.). 1) D
A) 15 B) 7.5 C) 1.5 D) 0.67 E) 3.3

$PV = nRT$ n, R V, T
$\frac{V_1}{T_1} = \frac{V_2}{T_2}$
$\frac{57.9\,L}{300.0\,K} = \frac{V_2}{423\,K}$
$\frac{(57.9)(423)}{300} = V_2$
$81.6\,L = V_2$

2) A sample of He gas (2.35 mol) occupies 57.9 L at 300.0 K and 1.00 atm. The volume of this sample is 81.6 L at 423 K and 1.00 atm. (4 pts.) 2) E
A) 1.41 B) 57.9 C) 41.1 D) 0.709 E) 81.6

3) One significant difference between gases and liquids is that _____. 3) C
A) a gas is made up of molecules
B) a gas may consist of both elements and compounds
C) a gas assumes the volume of its container
D) gases are always mixtures
E) All of the above answers are correct.

4) Gaseous mixtures _____. 4) B
A) can only contain molecules
B) are all homogeneous
C) are all heterogeneous
D) can only contain isolated atoms
E) must contain both isolated atoms and molecules

5) Which of the following equations shows an incorrect relationship between pressures given in terms of different units? 5) B
A) 0.760 atm = 578 mm Hg
B) 1.0 torr = 2.00 mm Hg
C) 1.00 atm = 760 torr
D) 1.20 atm = 122 kPa
E) 152 mm Hg = 2.03×10^4 Pa

6) Which statement about atmospheric pressure is false? 6) C
A) Atmospheric pressure prevents water in lakes, rivers, and oceans from boiling away.
B) As air becomes thinner, its density decreases.
C) With an increase in altitude, atmospheric pressure increases as well.
D) The warmer the air, the lower the atmospheric pressure.
E) Air actually has weight.

7) Of the following, only _____ is impossible for an ideal gas. 7) A

A) $V_1T_1 = V_2T_2$ $PV = nRT$ $\frac{V_1}{T_1} = \frac{V_2}{T_2}$

B) $\frac{V_1}{T_1} = \frac{V_2}{T_2}$

C) $\frac{V_1}{V_2} = \frac{T_1}{T_2}$ $V_1T_2 = V_2T_1$

D) $V_2 = \frac{T_2}{T_1}V_1$

E) $\frac{V_1}{V_2} = \frac{T_1}{T_2} = 0$

$PV = nRT$ $P = \frac{(1.241\ mol)(0.0821)(298K)}{1.2\ L}$ $P = 25.3\ atm$

$10.0\ g\ Ar \left(\frac{mol\ Ar}{39.948\ g}\right) = 0.250\ mol\ Ar$

$20.0\ g\ Ne \left(\frac{mol\ Ne}{20.179\ g}\right) = 0.991\ mol\ Ne$

$\chi_{Ne} = \frac{n_{Ne}}{n_{Tot}} = \frac{0.991}{0.991 + 0.250}$ $\chi_{Ne} = 0.799$

Ar 39.948 Ne 20.179

8) 10.0 grams of argon and 20.0 grams of neon are placed in a 1200.0 ml container at 25.0°C. The partial pressure of neon is _____ atm. (6 pts.) 8) E

A) 5.60 B) 8.70 C) 0.700 D) 3.40 E) 20.2

$P_{Ne} = \chi_{Ne}(P_{Tot}) = 0.799\ (25.3) = 20.2$

9) The average kinetic energy of the particles of a gas is directly proportional to _____. 9) E

A) the particle mass

B) the rms speed

C) the square of the particle mass

D) the square root of the rms speed

E) the square of the rms speed

$KE_{avg} = \frac{1}{2} m v_{rms}^2$

Least massive

10) Of the following gases, _____ will have the greatest rate of effusion at a given temperature. 10) B

A) Ar 40 B) CH_4 12 + 4 C) NH_3 14 + 3 D) HCl 1 + 35.5 E) HBr 1 + 80

$\frac{CH_4}{Ar}$ $\frac{16}{40}$

11) Arrange the following gases in order of increasing average molecular speed at 25 °C. (4 pts.) 11) D

4 32 44 28

He, O_2, CO_2, N_2

$v_{rms} = \sqrt{\frac{3RT}{M}}$

A) $CO_2 < N_2 < O_2 < He$

B) $He < N_2 < O_2 < CO_2$

C) $He < O_2 < N_2 < CO_2$

D) $CO_2 < O_2 < N_2 < He$

E) $CO_2 < He < N_2 < O_2$

$CO_2 < O_2 < N_2 < He$

$\frac{1}{2} m v^2 = const$

12) A mixture of two gases was allowed to effuse from a container. One of the gases escaped from the container 1.43 times as fast as the other one. The two gases could have been _____. (4 pts.) 12) A

A) Cl_2 and SF_6

B) O_2 and Cl_2

C) CO and SF_6

D) CO and CO_2

E) O_2 and SF_6

$1.43 = \frac{rate_1}{rate_2} = \sqrt{\frac{M_2}{M_1}}$

$\frac{rate\ Cl_2}{rate\ SF_6} = 1.43 = \sqrt{\frac{M_2}{M_1}} = \frac{\sqrt{(32.06) + 6(18.998)}}{\sqrt{2(35.45)}}$

13) A real gas will behave most like an ideal gas under conditions of _____. 13) D

A) STP
B) high temperature and high pressure
C) low temperature and low pressure
D) high temperature and low pressure
E) low temperature and high pressure

You will lose points if you dont show the (1) set up equation, (2) the raw data in the equation and (3) the appropriate units in your calculations.

14) An inflated baloon has a volume of 6.0 L at 1 atm pressure and at 22 °C. Calculate its volume when it ascends to an altitude where the pressure is 0.45 atm and the temperature is –21°C. (6 pts.) 14) 11 L

$PV = nRT$

$\frac{P_1V_1}{T_1} = nR = \frac{P_2V_2}{T_2}$

$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

$\frac{(1.0\,atm)(6.0\,L)}{(22+273)\,K} = \frac{(0.45\,atm)(V_2)}{(-21+273)}$

$\frac{6.0\,atm\cdot L}{295\,K} = \frac{0.45\,atm(V_2)}{252\,K}$

$(6.0\,atm\cdot L)(252\,K) = (295\,K)(0.45\,atm)(V_2)$

$11.4\,L = V_2$

$11\,L = V_2$

15) Calculate the density (in g/L) of NO_2 at 0.970 atm and 35 °C. (6 pts.) 15) 1.77 g/L

$d = \frac{PM}{RT}$

$d = \frac{(0.970\,atm)\left(\frac{14.0g + 2(16.0g)}{mol\ NO_2}\right)}{(0.082\ L\cdot atm/mol\cdot K)(35+273K)}$

$d = \frac{(0.97\,atm)(46\,g/mol)}{(25.256\ L\cdot atm/mol)}$

$d = 1.77\ g/L$

16) An evacuated flask weighs 134.567 g. When filled with an unknown gas at 735 torr and 31°C, it weighs 137.456 g. If the flask is filled with water at 31°, it weighs 1067.9 g. If the ideal gas law applies and the density of water at 31 °C is 0.997 g/mL, then calculate the molar mass of the unknown gas. (10 pts.)

16) 80.25 g/mol

Unknown gas: Δ Mass = 137.456 g − 134.567 g

Δ mass = 2.889 g

Water: Δ mass = 1067.9 g − 134.567

Δ mass = 933.3 g

$933.3\text{ g } H_2O \left(\frac{\text{mL}}{0.997\text{ g}}\right) = 936\text{ mL}$

= Volume of flask

$PV = nRT$

$\left(\frac{735\text{ torr}}{760\text{ torr}}\right)(0.936\text{ L}) = n\left(0.082\frac{\text{L atm}}{\text{mol K}}\right)(31+273\text{ K})$

$\frac{(0.97\text{ atm})(0.936\text{ L})}{\left(0.082\frac{\text{L atm}}{\text{mol K}}\right)(304\text{ K})} = n$

$0.036\text{ mol} = n$

$M = \frac{\text{mass}}{\text{moles}}$

$M = \frac{2.889\text{ g}}{0.036\text{ mol}}$

$M = 80.25\text{ g/mol}$

17) Magnesium reacts with oxygen: Mg + O_2(g) --> MgO(s). How many grams of Magneium would react with all the oxygen in a 87.4 L container at 27 °C and 3.5×10^{-7} torr pressure? (8 pts.)

17) 8.0×10^{-8} g Mg

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

$PV = nRT$

$\frac{PV}{RT} = n$

$\frac{\left(3.5 \times 10^{-7}\text{ torr}\right)\left(\frac{1\text{ atm}}{760\text{ torr}}\right)(87.4\text{ L})}{\left(0.082\text{ L atm/mol K}\right)(27+273\text{ K})} = n$

$1.64 \times 10^{-9}\text{ mol of } O_2 = n$

$1.64 \times 10^{-9}\text{ mol } O_2 \left(\frac{2\text{ moles Mg}}{1\text{ mol } O_2}\right) = 3.27 \times 10^{-9}\text{ mol Mg}$

$3.27 \times 10^{-9}\text{ mol Mg}\left(\frac{24.3\text{ g}}{1\text{ mol Mg}}\right) = 7.95 \times 10^{-8}\text{ g Mg}$

8.0×10^{-8} g Mg

18) Oxygen gas is produced by decomposing $KClO_3$ as follows: $2\ KClO_3 \rightarrow 2\ KCl\ (s) + 3\ O_2\ (g)$. If 0.25 L of oxygen was collected over water at 26 °C and 765 torr pressure, calculate the moles of oxygen collected. Vapor pressure of water at 26 °C is 25 torr. (6 pts.)

9.9×10^{-3} mole O_2

18) ~~1.1 x 10^{-2} mol~~ O_2

$P_{Total} = P_{gas} + P_{H_2O}$

$765\ torr = P_{O_2} + 25\ torr$

$P_{O_2} = 765 - 25 = 740\ torr$

$= 740 \times \frac{1\ atm}{760\ torr}$

$= 0.974\ atm$

$PV = nRT, \quad n = \frac{PV}{RT} = \frac{(0.974\ atm) \times (0.25\ L)}{.082\ \frac{L \cdot atm}{K \cdot mol} \times (26+273)\ K}$

$n = \frac{.974 \times .25}{.082 \times 299} = 0.00993 = 9.9 \times 10^{-3}\ mol\ O_2$

~~$P_{Total} = 765\ torr + 25\ torr$~~

~~$P_{total} = 790\ torr \left(\frac{1\ atm}{760\ torr}\right)$~~

~~$P_{total} = 1.04\ atm$~~

$PV = nRT$

$\frac{PV}{RT} = n$

~~$\frac{(1.04\ atm)(0.25\ L)}{(0.082\ L\ atm/mol\ K)(26+273)\ K} = n$~~

~~$1.06 \times 10^{-2}\ mol\ O_2 = n$~~

~~$1.1 \times 10^{-2}\ mol\ O_2$~~

19) An unknown gas, X_2 effuses at a rate that is 0.355 times that of O_2 molecules at the same temperature. Calculate the molar mass of the gas (6 pts.) and its identity (2 pts.) Given $r_1/r_2 = (M_2/M_1)^{1/2}$. (Total 8 pts.)

19) 253.9 g/mol

Identity is Iodine gas I_2

(1) rate X_2 = 0.355 (rate of O_2)

$\frac{\text{rate } X_2}{\text{rate } O_2} = \frac{0.355}{1} = \sqrt{\frac{M_{O_2}}{M_{X_2}}}$

$0.355 = \frac{\sqrt{32.0\ g/mol}}{\sqrt{M_{X_2}}}$

$\sqrt{M_{X_2}} = \frac{\sqrt{32.0\ g/mol}}{0.355}$

$\sqrt{M_{X_2}} = 15.93$

$M_{X_2} = 253.9\ g/mol$

$\frac{253.9}{2} = 126.95$ ~ M of I

so gas is I_2

20) The body centered cubic unit cell of a crystalline element has the edge length is 2.8664 °A. If the density of the crystal is 7.92 g/cm^3, the calculate the atomic weight of the element. (8 pts.)

20) 56.2 g/mol

$V = s^3$

$V = (2.8664 \times 10^{-10}\ m)^3$

$V = (2.355 \times 10^{-29}\ m^3)\left(\frac{100\ cm}{m}\right)^3$

$V = 2.355 \times 10^{-23}\ cm^3$

$\rho = \frac{\text{mass of unit cell}}{\text{Volume of unit cell}}$ ← Ni atom

$7.92\ g/cm^3 = \frac{\text{mass of unit cell}}{2.355 \times 10^{-23}\ cm^3}$

$1.865 \times 10^{-22}\ g$ = mass unit cell

1 unit cell = 2 atoms

$\frac{1.865 \times 10^{-22}\ \text{mass of unit cell}}{2\ \text{atoms per unit cell}} = \frac{9.325 \times 10^{-23}\ g}{atom}$

$\left(\frac{9.325 \times 10^{-23}\ g}{atom}\right)\left(\frac{6.023 \times 10^{23}\ atoms}{1\ mol}\right)$

$56.164\ g/mol$

Answer if the statement is true or false (2 pts.) and then briefly explain your reasoning (2 pts.).

21) If the temperature is lowered from 60 °C to 30°C, the volume of a fixed amount of gas will be one half the original volume. T or (F)

If P is const. $PV = nRT$, $V = \frac{nRT}{P}$, $\frac{V_1}{T_1} = \frac{V_2}{T_2}$, $\frac{V_1}{273+60} = \frac{V_2}{30+273}$, $\frac{V_2}{V_1} = \frac{303}{333} \neq \frac{1}{2}$

22) A gas is considered "ideal" if one mole of it in a one-liter container exerts a pressure of exactly 1 atm at room temperature. T or F

Ideal gases obey $PV = nRT$; $(1)(1) = (1)\,R\,(298)$; $1 \neq (298K)R$

23) According to the kinetic-molecular theory, molecules of different gases at the same temperature always have the same average kinetic energy. T or F

Yes, $KE_{avg} \propto T$ in K

24) The effusion rate of a gas is proportional to the square root of its molar mass. T or F

No, $\text{rate}_1 \propto \frac{1}{\sqrt{M_1}}$ thus it is inversely proportional