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# ANSWER KEY

CHEMISTRY F14O3 SECOND EXAM 11/10/99
PROFESSOR J. MORROW

PRINT NAME, LAST: ______________________

FIRST: ______________________

I.D.# : ______________________

MAXIMUM POINT VALUE IS IN PARENTHESES

| | | |
|---|---|---|
| 1. ________ (15) | 9. ________ (15) | 17. ________ (6) |
| 2. ________ (15) | 10. ________ (15) | 18. ________ (15) |
| 3. ________ (6) | 11. ________ (6) | 19. ________ (15) |
| 4. ________ (12) | 12. ________ (6) | 20. ________ (15) |
| 5. ________ (15) | 13. ________ (6) | 21. ________ (6) |
| 6. ________ (6) | 14. ________ (6) | 22. ________ (6) |
| 7. ________ (15) | 15. ________ (15) | 23. ________ (15) |
| 8. ________ (6) | 16. ________ (6) | 24. ________ (6) |

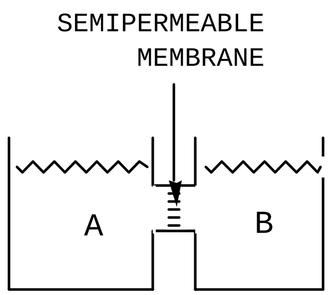
COLUMN TOTALS (MAXIMUM):

________(90) ________(75) ________(84)

EXAM TOTAL (201 pts) ____________ ____________
OUT OF 1OO

THE FOLLOWING IN FORMATION IS FOR USE IN PROBLEMS 1, 2, AND 3.

You are given the following system of two beakers separated by a semipermeable membrane. Beaker A contains a 0.100 M solution of $Al(NO_3)_3$.
Beaker B contains a 0.120 M solution of $Ca(NO_3)_2$. The contents in both beakers are 100 % ionized. The volume of each solution is 500 mL and their densities are 1.00 g/mL. As a result of these initial conditions there is an osmotic pressure difference between the two beakers which would require that water pass from one beaker to the other beaker to equalize their osmotic pressures. The density of "pure" water is 1.00 g/mL. $R = 0.0821 \frac{L \cdot atm}{deg \cdot mol}$




1) Calculate the direction of water flow and the volume of water required to equalize their osmotic pressures. (15 pts) SHOW WORK

a) A —> B 26.3 mL  b) B —> A 26.3 mL  c) A —> B 45.4 mL  d) B —> A 45.4 mL  e) A —> B 20.0 mL  f) B —> A 20.0 mL

Water must go from beaker B —> A so both beakers will have the same mL/mol ratio.

$$\therefore \frac{500 + x}{0.20 \text{ mol of ions}} = \frac{500 - x}{0.18 \text{ mol of ions}} \qquad X = 26.3 \text{ mL}$$

where 0.20 mol of ions = $\left(\frac{4 \text{ ions}}{\text{mol of } Al(NO_3)_3}\right)(0.10 \text{ M})(0.500 \text{ L})$

and 0.18 mol of ions = $\left(\frac{3 \text{ ions}}{\text{mol of } Ca(NO_3)_2}\right)(0.12 \text{ M})(0.500 \text{ L})$

THIS IS THE SIMPLEST WAY OF OBTAINING THE ANSWER. YOU CAN ALSO SOLVE THIS BY GETTING THEIR MOLARITIES TO BE EQUAL OR THEIR MOLALITIES TO BE EQUAL.

IF ANSWER GIVEN IS c, GIVE 10 PTS.

ANSWER IS: b

2) Referring back to the initial setup, what mass of $NaNO_3$ would have to be added (and to which beaker) to equalize the osmotic pressures thereby preventing water from flowing from one beaker to the other beaker? Assume the $NaNO_3$ (100 % ionized) is added without changing the solutions volume. Molar mass of $NaNO_3$ is 85.0 $\frac{g}{mol}$ . (15 pts) SHOW WORK

a) beaker A 3.40 g   b) beaker B 3.40 g   c) beaker A 1.70 g   d) beaker B 1.70 g   e) beaker A 0.85 g   f) beaker B 0.85 g

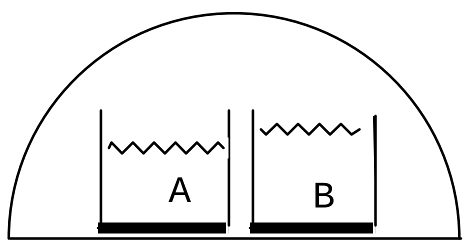
AT THE END, THE TOTAL # OF MOLES OF ALL IONS IN EACH BEAKER MUST BE THE SAME.
∴ YOU MUST ADD 0.020 MOL OF IONS OR 0.010 MOL OF $NaNO_3$ MUST BE ADDED TO BEAKER B.

WEIGHT OF $NaNO_3$ = (0.010 mol)(85.0 $\frac{g}{mol}$ ) = 0.85 g

IF ANSWER GIVEN IS <u>e</u> , GIVE 10 PTS.

ANSWER IS: <u>f</u>

3) If the cell configuration was




but the contents were the same as originally described in question 1, in which direction does water pass, and what is its volume? HINT: The cells originally have different vapor pressures, therefore water will distill from the beaker of higher vapor pressure to the beaker of lower vapor pressure. (6 pts)

THE ANSWER IN THIS QUESTION IS THE SAME AS THEIR ANSWER FROM QUESTION 1.

a) A —> B 26.3 mL   b) B —> A 26.3 mL   c) A —> B 45.4 mL   d) B —> A 45.4 mL   e) A —> B 20.0 mL   f) B —> A 20.0 mL

ANSWER IS: _____

4) Consider the the following equilibrium reaction at $25^oC$.

$$NH_{3(g)} + NI_{3(s)} \rightleftharpoons 3\,HI_{(\ell)} + N_{2(g)} \quad \Delta H = +2O.O\ kJ$$

In which direction will the reaction (originally at equilibrium) shift
(to the LEFT, to the RIGHT, or remain UNCHANGED), if (12 points)

a) A catalyst is added. ANSWER IS: UNCHANGED

b) The volume is decreased. (Think of the container as a piston.)
ANSWER IS: UNCHANGED

c) The temperature is lowered. ANSWER IS: LEFT

d) The total pressure is increased by adding helium.
ANSWER IS: UNCHANGED

e) Some $N_2$ is added. ANSWER IS: LEFT

f) Some HI is removed. ANSWER IS: UNCHANGED

5) A 1.5O M ($\frac{mol}{L}$) solution of glucose, $C_6H_{12}O_6$ (F = 18O $\frac{g}{mol}$) , in water has a density of 1.2O $\frac{g}{cm^3}$ .
Glucose is a nonvolatile solute . At $25^oC$ the vapor pressure of water is 23.8 torr . Calculate :
(15 pts) SHOW WORK

a) The mole fraction of water. (5 pts)
1.50 mol is 270 g dissolved in 1 L (= 1200 g of solution)
$n_{Glu}$ = 1.50 , $n_{H2O}$ = 930/18 = 51.7 mol
$\therefore$ $X_{H2O}$ = 51.7/(51.7 + 1.5) = 0.972 ANSWER IS: 0.972

b) The molality (in terms of glucose) of this solution. (5 pts)
$m_{Glu}$ = 1.50 mol/0.930 kg $H_2O$ = 1.61 m
ANSWER IS: 1.61 m

c) The vapor pressure of this solution (in torr) if one (1) more mol of glucose was added to the above solution. (5 pts)
$\therefore$ $X_{H2O}$ = 51.7/(51.7 + 2.5) = 0.954 AND P = (0.954)(23.8) = 22.7 torr

ANSWER IS: 22.7

THE FOLLOWING INFORMATION IS FOR PROBLEMS 6, 7, AND 8.

Given the following gaseous reaction:

$$C_3H_4 + 4\,Cl_2 \longrightarrow C_3H_2Cl_6 + 2\,HCl$$

The two reactants (1 mol of each) are each at STP in a volume of 22.4 L.

6) The reaction proceeds until the total pressure, $P_T$ , is 1.6O atm. At this total equilibrium pressure all four compounds (both reactants and both products) are present. Calculate the density of the initial (starting) mixture.

Molar masses: $C_3H_4$ (4O.O) ; $Cl_2$ (71.O) ; $C_3H_2Cl_6$ (251.O) ; HCl (35.5)

$$\text{DENSITY} = \frac{40.0 + 71.0}{22.4} = 4.96\ \frac{g}{L}$$

(6 pts) ANSWER IS: $\underline{4.96}\ \frac{g}{L}$

7) Calculate the partial pressures of $C_3H_4$ , $Cl_2$ , $C_3H_2Cl_6$ , and HCl at the total equilibrium pressure of 1.6O atm. SET UP THE EQUATIONS BELOW (7 pts) THAT WILL ALLOW YOU TO SOLVE FOR THE PRESSURES. DO THE CALCULATIONS ON SCRAP PAPER AND INSERT NUMERICAL ANSWERS WHERE INDICATED BELOW!

$$P_T = 1.60 = P_{C_3H_4} + P_{Cl_2} + P_{C_3H_2Cl_6} + P_{HCl}$$

$$P_T = 1.60 = (1 - x) + (1 - 4x) + x + 2x = 2 - 2x$$

WHERE x = PRESSURE OF $C_3H_4$ **LOST**

For $C_3H_4$ , P = $\underline{0.80}$ (2 pts) For $Cl_2$ , P = $\underline{0.20}$ (2 pts)

For $C_3H_2Cl_6$ , P = $\underline{0.20}$ (2 pts) For HCl , P = $\underline{0.40}$ (2 pts)

8) The equilibrium expression for $K_{P(atm)}$ where $P_T$ is the total pressure at equilibrium is; (6 pts)

a) $\frac{(2\text{-}O.5P_T)(1\text{-}P_T)^2}{(O.5P_T)(2P_T\text{-}3)^4}$ b) $\frac{(1\text{-}O.5P_T)(2\text{-}P_T)^2}{(O.5P_T)(2P_T\text{-}3)^4}$

c) $\frac{(O.5P_T)(2\text{-}P_T)^2}{(1\text{-}O.5P_T)(2P_T\text{-}3)^4}$ d) $\frac{(1\text{-}O.5P_T)(2\text{-}P_T)^4}{(O.5P_T)(2P_T\text{-}3)^2}$

ANSWER IS: b

9) What is the partial pressure of $SO_2$ (in torr), if equal masses of $O_2$ and $SO_2$ are mixed and the total pressure is 600 torr?

Molar masses: $O_2$ (32 g), $SO_2$ (64 g) SHOW WORK (15 pts)

a) 500 b) 400 c) 300 d) 200 e) 100

ASSUME 64 g OF EACH COMPOUND. ∴ mol $SO_2$ = 1.0 AND mol $O_2$ = 2.0
MOLE FRACTION OF $SO_2$ = 1/3 AND $P_{SO2}$ = (1/3)(600) = 200 torr

ANSWER IS: d

10) You have a container of gas X and a container of gas Y, and the following information: the two gases are ideal; they are at the same temperature; the molar mass of Y is twice that of X; the density of Y is half that of X. What is the ratio of the pressures of gas X to gas Y, ($\frac{P_X}{P_Y}$), in the two containers? (15 pts)

a) $\frac{1}{4}$ b) $\frac{1}{2}$ c) 1 d) 2 e) 4

$P_x = \frac{(\text{density of X})(RT)}{F_x}$ AND $P_y = \frac{(\text{density of Y})(RT)}{F_Y}$

$\therefore \quad \frac{P_X}{P_Y} = 4$

ANSWER IS: e

11) Calculate the universal gas constant , R, in the following units, $\frac{L\cdot Pa}{K\cdot mol}$ .

$(\frac{L\cdot Pa}{K\cdot mol}) = (\frac{L\cdot atm}{K\cdot mol})(\frac{Pa}{atm}) = (0.0821)(1.0135x10^5) = 8.32x10^3$

(6 pts) ANSWER IS: $8.32x10^3 \; \frac{L\cdot Pa}{K\cdot mol}$

12) At room temperature mercury has a density of 13.6 $\frac{g}{cm^3}$ while liquid bromoform, $CHBr_3$, has a density of 2.89 $\frac{g}{cm^3}$. How high a column of bromoform will be supported by a pressure that supports a column of mercury 200 mm high? (6 pts)

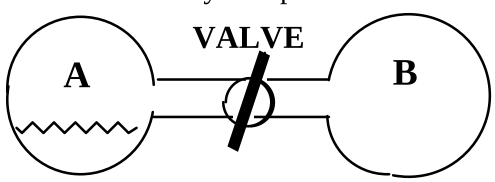
a) 94.1 mm b) 272.0 mm c) 42.5 cm d) 94.1 cm e) 272.0 cm

$$d_{Hg}gh_{Hg} = d_{CHBr_3}gh_{CHBr_3} \quad \therefore \quad d_{Hg}h_{Hg} = d_{CHBr_3}h_{CHBr_3}$$

$$h_{CHBr_3} = \frac{d_{Hg}h_{Hg}}{d_{CHBr3}} = \frac{(13.6)(200)}{2.89} = 941 \text{ mm} = 94.1 \text{ cm}$$

ANSWER IS: <u>d</u>

13) Two 500.0 mL bulbs are connected by a stopcock.




Bulb B is evacuated. The other bulb, A, contains 100.0 g of liquid chloroform in equilibrium with its vapor. Both bulbs are maintained at 20.0$^{o}$C. At this temperature the density of <u>liquid</u> chloroform is 1.4925 $\frac{g}{cm^3}$ and its vapor pressure is 159.6 torr. The valve between the two bulbs is now opened. Estimate the volume of liquid (in $cm^3$) remaining in bulb A, when equilibrium is established? Neglect the volume decrease of the liquid in calculating the volume of the gas after the stopcock is opened. (6 pts)

a) 100 $cm^3$ b) 67 $cm^3$ c) 50 $cm^3$ d) 33 $cm^3$ e) 0 $cm^3$

ONLY THE VAPOR PRESSURES IN BOTH BULBS MUST BE EQUAL, <u>NOT THEIR</u> VOLUMES.

IF ANSWER GIVEN IS <u>a</u>, GIVE 4 PTS.

ANSWER IS: <u>b</u>

14) Given the following <u>gaseous</u> reactions.

1. $3\ HF + C_3H_4F_2 \rightleftharpoons C_3HF_5 + 3\ H_2$ $K_1$
2. $F_2 + C_3HF_5 \rightleftharpoons C_3F_6 + HF$ $K_2$
3. $2\ F_2 + 2\ C_3H_4F_2 \rightleftharpoons C_6H_6F_6 + 2\ HF$ $K_3$

Calculate the equilibrium constant $K_4$ (for reaction 4) in terms of $K_1$, $K_2$, and $K_3$.

4. $2\ C_3F_6 + 6\ H_2 \rightleftharpoons C_6H_6F_6 + 6\ HF$ $K_4 = ?$

a) $\frac{K_3}{K_1^2K_2}$ b) $\frac{K_3}{K_1K_2^2}$ c) $\frac{K^2_3}{K_1^2K_2^2}$ d) $\frac{K_3}{K_1^2K_2^2}$

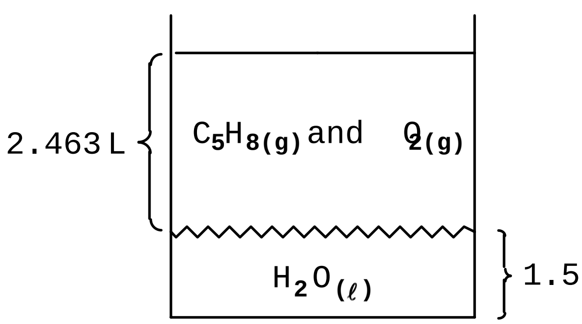
e) $K_1K^2_2K_3$ f) $\frac{K_1^2K_3}{K_2^2}$ g) $K_1K_2K^2_3$ h) $\frac{K_1K_3}{K_2^2}$

(6 pts) ANSWER IS: <u>d</u>

15) The following reaction occurs in a vessel of 2.463 L volume at 27$^o$C.

$$C_5H_{8(g)} + 7\ O_{2(g)} \longrightarrow 5\ CO_{2(g)} + 4\ H_2O_{(\ell)}$$

Initially, 1.OO atm of $C_5H_{8(g)}$ and 1.OO atm of $O_{2(g)}$ are mixed in the 2.463 L volume above the 1.5 L of liquid $H_2O$ .




The reaction then goes to completion. The temperature remains constant at 27$^o$C. The vapor pressure of water at 27$^o$C is 27 torr. What is the <u>total</u> pressure (after reaction) in the 2.463 L volume above the 1.5 L of liquid $H_2O$ ? SHOW WORK (15 pts)

a) 1194 torr b) 651 torr c) 1221 torr d) 678 torr

At end of reaction 5/7 atm of $CO_2$is formed and 6/7 atm of $C_5H_8$ remains

$P_T$ = 542.9 + 651.4 + 27.0 (from water vapor) = 1221 torr

IF ANSWER GIVEN IS a, GIVE 8 PTS. ANSWER IS: <u>c</u>

16) In the following group of three molecules, predict their relative

normal boiling points: $GeCl_4$ , $AsCl_3$ , and $SnCl_4$ .

Molar masses: $GeCl_4$ (214) ; $AsCl_3$ (181) ; $SnCl_4$ (26O)

a) $GeCl_4 > AsCl_3 > SnCl_4$  b) $AsCl_3 > SnCl_4 > GeCl_4$

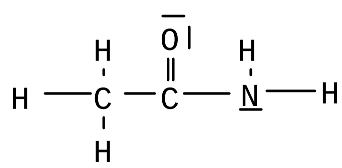
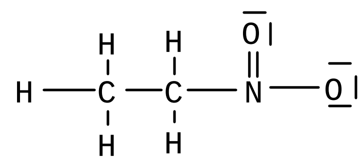
c) $AsCl_3 > GeCl_4 > SnCl_4$  d) $GeCl_4 > SnCl_4 > AsCl_3$

$AsCl_3 > SnCl_4 > GeCl_4$ <u>actual values</u>: 4O3 K > 384 K > 357 K

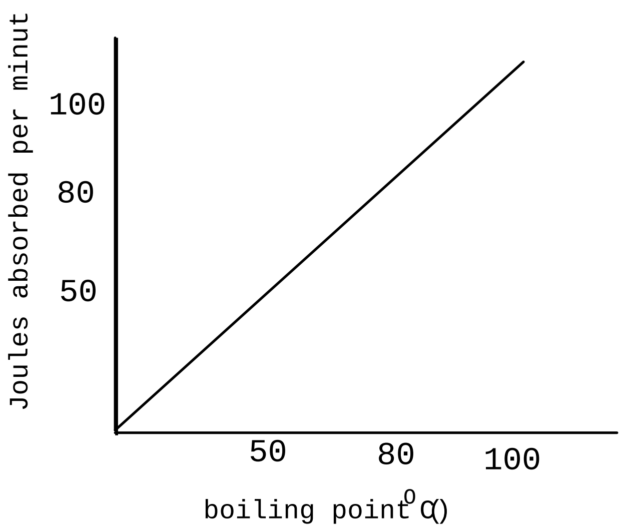
(6 pts) ANSWER IS: <u>b</u>

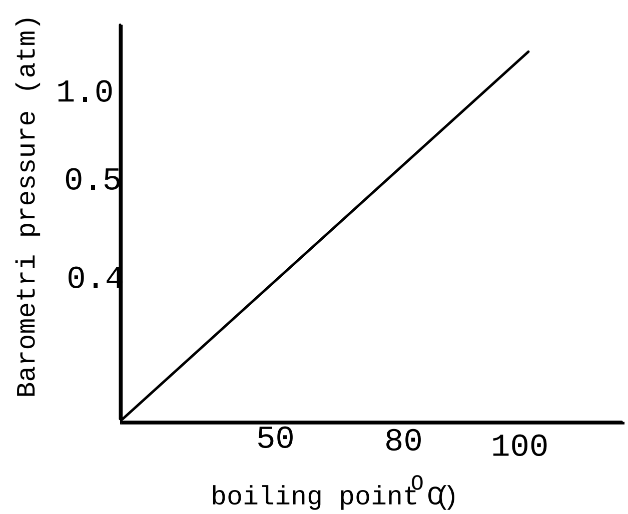
17) In each of the following pairs of covalent molecules, <u>CIRCLE</u> the one with the higher normal boiling point. (6 pts - 3 pts each)

a) $CH_3CH_2OCH_2CH_3$ or $CH_3CH_2SCH_2CH_3$

b)  or 

18) Given the following information,




How long (in min) would it take to cook the equivalent of a 3 minute "Earth Egg" (at a barometric pressure of 1 atm) on a planet where the barometric pressure is half that of earth? (15 pts)
SHOW WORK

Joules absorbed in 3 minutes at $100^{O}C$ on Earth = (100)(3) = 300 J
On the other planet the egg absorbs 80 J/min since the pressure is 0.5 atm
$\therefore$ time of cooking = (300 J)/(80 J/min) = 3.75 min (OR 3 min and 45 sec)

ANSWER IS: <u>3.75 min</u>

19) For a reaction of the type $A_{(g)} + 2\,B_{(g)} \rightleftharpoons 2\,C_{(g)}$, an equilibrium mixture consists of 3.0 mol of A, 0.80 mol of B, and 0.40 mol of C, in a 2.00 L flask. What is the value of $K_p$ for this reaction at 300 K? (15 pts) SHOW WORK

a) 0.020 b) 0.0134 c) 0.010 d) 0.0067 e) 0.0034

[A] = 1.50 M [B] = 0.40 M [C] = 0.20 M $\therefore\ K_c = \dfrac{(0.20)^2}{(1.50)(0.40)^2} = 0.166$

$$K_p = K_c(RT)^{\Delta n} = (0.166)\{(0.0821)(300)\}^{-1} = 0.00674$$

YOU CAN ALSO SOLVE FOR $K_P$ DIRECTLY. $K_P = \dfrac{(4.926)^2}{(36.9)(9.85)^2} = 0.0067$

WHERE $P_A = \dfrac{n_A RT}{V}$, $P_B = \dfrac{n_B RT}{V}$, AND $P_C = \dfrac{n_C RT}{V}$

ANSWER IS: <u>0.0067</u>

20) Given pure ethylene glycol (EG), and pure water (W).
The molar masses are 62.0 $\frac{g}{mol}$ for EG, and 18.0 $\frac{g}{mol}$ for W.
The densities of EG and of W are 0.800 $\frac{g}{mL}$ and 1.000 $\frac{g}{mL}$ respectively.
You want to prepare 3OO mL of a solution with a mass of 270 g. Assume the volumes are additive. The masses of pure EG and of pure W which will give you the desired solution are, (15 pts) SHOW WORK

a) 120 g of EG and 150 g of W.
b) 140 g of EG and 130 g of W.
c) 150 g of EG and 120 g of W.
d) 130 g of EG and 140 g of W.

$$V_{total} = 3OO\ mL = V_{EG} + V_{H2O} = \frac{w_{EG}}{d_{EG}} + \frac{w_{H2O}}{d_{H2O}}$$

$$W_{total} = 270\ g = W_{EG} + W_{H2O}$$

$$3OO\ mL = \frac{w_{EG}}{d_{EG}} + \frac{w_{H2O}}{d_{H2O}} = \frac{w_{EG}}{0.800} + \frac{270-w_{EG}}{1.00}$$

$W_{EG} = 120$ g and $W_{H2O} = 150$ g

ANSWER IS: <u>a</u>

21) What is the mole fraction of EG in the above solution?
CREDIT FOR THIS PART IS BASED ON YOUR ANSWER FROM QUESTION 20. (6 pts)

a) 0.188 b) 0.238
c) 0.266 d) 0.212

ANSWER IS: ________

22) Using water (W) as the solvent, what is the molality of the above solution?
CREDIT FOR THIS PART IS BASED ON YOUR ANSWER FROM QUESTION 20. (6 pts)

a) 12.9 m b) 17.4 m
c) 20.1 m d) 15.0 m

ANSWER IS: ________

23) What volume of $CO_2$ (at STP) can be produced when 15.0 g of $C_2H_6$ and 64.0 g of $O_2$ are reacted according to; (15 pts) SHOW WORK

$$2\ C_2H_{6(g)} + 7\ O_{2(g)} \longrightarrow 4\ CO_{2(g)} + 6\ H_2O_{(\ell)}$$

a) 20.0 L b) 22.4 L c) 25.6 L d) 33.6 L e) 21.9 L

$$n_{C2H6} = \frac{15.0}{30.0} = 0.50 \qquad n_{O2} = \frac{64.0}{32.0} = 2.00$$

$C_2H_6$ is limiting. $\therefore\ n_{CO2} = \frac{4}{2}(n_{C2H6}) = 2(0.50) = 1.00$ mol

$$V_{CO2} = (1.00\ \text{mol})(22.4\ \text{L/mol}) = 22.4\ \text{L}$$

IF ANSWER GIVEN IS **<u>C</u>**, GIVE 6 PTS.

ANSWER IS: <u>b</u>

24) What is the molar mass of a gas, 5.25 g of which occupy 1.25 L at 3O.O$^{o}$C and O.915 atm pressure? (6 pts)

a) 28.O g/mol b) 114 g/mol c) 146 g/mol d) 52 g/mol e) 64 g/mol

$$F = \frac{wRT}{PV} = \frac{(5.25)(0.0821)(303.2)}{(0.915)(1.25)} = 114 \text{ g/mol}$$