

Second Exam

1. IF 636.0 ml of nitrogen gas, measured at 488.9 mmHg and 22.3°C reacts with excess iodine according to the following reaction, what mass of nitrogen triiodide is produced? $N_2(g) + 3I_2(s) \rightarrow 2NI_3(s)$

- a. 3.33 g
- b. 0.472 g
- c. 176 g
- d. **13.3 g**
- e. 6.66 g

$$* V_{N_2} = 0.636 \text{ L}$$

$$P = 488.9 \text{ mmHg} + \frac{1 \text{ atm}}{760 \text{ mmHg}} = 0.643 \text{ atm}$$

$$T = 22.3^\circ\text{C} = 22.3 + 273 = 295.3 \text{ K}$$

$$m_{NI_3} = ?$$



Limiting reagent
excess reagent

$$\Rightarrow PV = nRT \Rightarrow n_{N_2} = \frac{PV}{RT} = \frac{0.643 \text{ atm} \times 0.636 \text{ L}}{0.0821 \text{ atm}\cdot\text{L} \cdot \text{mol}^{-1}\cdot\text{K} \times 295.3}$$

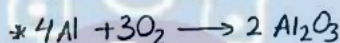
$$n_{N_2} = 0.01687 \text{ mol}$$

$$1 \text{ mol } N_2 \rightarrow 2 \text{ mol } NI_3$$

$$0.01687 \text{ mol} \rightarrow \frac{m}{391.72 \text{ g/mol}} \Rightarrow m = 2 \times 0.01687 \times 391.72 = 13.3 \text{ g} \checkmark$$

2. How much heat is evolved upon the complete oxidation of 6g of aluminum at 25°C and 1 atm pressure? (For Al_2O_3 is -1676 kJ/mol .) $4Al(s) + 3O_2(g) \rightarrow 2Al_2O_3(s)$

- a. 85.51 kJ
- b. **186 kJ**
- c. 342.3 kJ
- d. 684.7 kJ
- e. $9.238 \times 10^3 \text{ kJ}$



$$n_{Al} = \frac{6 \text{ g}}{27 \text{ g/mol}} = 0.222 \text{ mol}$$

$$n_{Al_2O_3} = \frac{1}{2} n_{Al} = 0.111 \text{ mol}$$

$$\text{heat evolved (q)} = -\Delta H \times n_{Al_2O_3}$$

$$= 1676 \times 0.111$$

$$= 186 \text{ kJ} \checkmark$$

3. A 86.9-g sample of Chromium ($s = 0.447 \text{ J/(g}\cdot^\circ\text{C)}$), initially at 338.33°C , is added to an insulated vessel containing 181.9 g of water ($s = 4.18 \text{ J/(g}\cdot^\circ\text{C)}$), initially at 16.17°C . At equilibrium, the final temperature of the metal-water mixture is 28.06°C . How much heat was absorbed by the water? The heat capacity of the vessel is $0.220 \text{ kJ/}^\circ\text{C}$.

- a. **9.43 kJ**
- b. 15.2 kJ
- c. 12 kJ
- d. 6.52 kJ
- e. 112 kJ

$$* \text{ For Chromium: } m = 86.9 \text{ g, } s = 0.447 \text{ J/(g}\cdot^\circ\text{C)}$$

$$t_i = 338.33^\circ\text{C, } t_f = 28.06^\circ\text{C} \Rightarrow q_{Cr} = ms\Delta t$$

$$= 86.9 \times 0.447 \times (28.06 - 338.33)$$

$$= -12052 \text{ J} = -12.052 \text{ kJ}$$

$$* \text{ The vessel: } C = 0.22 \text{ kJ/}^\circ\text{C}$$

$$t_i = 16.17^\circ\text{C, } t_f = 28.06^\circ\text{C}$$

$$\Rightarrow q_{\text{vessel}} = C\Delta t$$

$$= 0.22 \times (28.06 - 16.17)$$

$$= 2.616 \text{ kJ}$$

$$* \text{ for water: } q_{H_2O} = ?$$

$$-q_{Cr} = q_{\text{vessel}} + q_{H_2O} \Rightarrow q_{H_2O} = -q_{Cr} - q_{\text{vessel}}$$

$$= -(-12.052) - 2.616$$

$$= 9.436 \text{ kJ} \checkmark \rightarrow \text{heat absorbed by water}$$

4. What volume of sulfur trioxide gas, SO_3 , has the same number of atoms as 4 L of helium gas at the same temperature and pressure?

- a. 4 L
- b. 20 L
- c. 16 L
- d. **1 L**
- e. 0.8 L

$$* V_{SO_3} = ?$$

SO_3 has the same number of atoms as 4 L of $He(g)$

$$1 \text{ mol } SO_3 \rightarrow 4 \text{ mol atoms}$$

$$1 \text{ mol } He \rightarrow 1 \text{ mol atoms}$$

$$\Rightarrow 4 \text{ mol } He \rightarrow 1 \text{ mol } SO_3$$

$$4 \text{ L } He \rightarrow V_{SO_3} \Rightarrow V_{SO_3} = \frac{4}{4} = 1 \text{ L} \checkmark$$

5. In a certain experiment, 0.7000 mol of hydrogen gas reacted with 0.7000 mol of solid iodine at a constant 1 atm pressure, producing 1.4000 mol of solid hydrogen iodide and absorbing 36.9 kJ of heat in the process. Which of the following thermochemical equations correctly describes this experiment?

- a. $H_2(g) + I_2(s) \rightarrow 2HI(s), \Delta H^\circ = 73.8 \text{ kJ}$
- b. $H_2(g) + I_2(s) \rightarrow 2HI(s), \Delta H^\circ = -36.9 \text{ kJ}$
- c. $H_2(g) + I_2(s) \rightarrow 2HI(s), \Delta H^\circ = 36.9 \text{ kJ}$
- d. $H_2(g) + I_2(s) \rightarrow 2HI(s), \Delta H^\circ = -52.72 \text{ kJ}$
- e. $H_2(g) + I_2(s) \rightarrow 2HI(s), \Delta H^\circ = 52.72 \text{ kJ}$

* $n_{H_2} = 0.7 \text{ mol}$
 $n_{I_2} = 0.7 \text{ mol}$
 $P = 1 \text{ atm}$
 $n_{HI} = 1.4 \text{ mol}$
 $q = +36.9 \text{ kJ}$
 absorbs heat \Rightarrow endothermic $\Rightarrow \Delta H = +ve$

$H_2 + I_2 \rightarrow 2HI$

$1.4 \text{ mol HI} \rightarrow 36.9$
 $2 \text{ mol HI} \rightarrow \Delta H$
 $\Rightarrow \Delta H = \frac{36.9 \times 2}{1.4} = 52.72 \text{ kJ} \checkmark$

6. A bomb calorimeter has a heat capacity of 2.47 kJ/K, when a 0.106-g sample of a certain hydrocarbon was burned in this calorimeter, the temperature increased by 2.14 K. Calculate the energy of combustion for 1 g of the hydrocarbon.

- a. $-2.33 \times 10^3 \text{ J/g}$
- b. -0.560 J/g
- c. $-4.99 \times 10^5 \text{ J/g}$
- d. -5.29 J/g
- e. -0.120 J/g

* $C = 2.47 \text{ kJ/K}$
 $\Delta t = 2.14$
 $m = 0.106 \text{ g}$
 $q = -q_{cal} = -C\Delta t$
 $= -2.47 \times 2.14$
 $= -5.29 \text{ kJ}$

$0.106 \text{ g} \rightarrow -5.29 \text{ kJ}$
 $1 \text{ g} \rightarrow x \Rightarrow x = \frac{-5.29 \text{ kJ}}{0.106 \text{ g}}$
 $= -49.9 \frac{\text{kJ}}{\text{g}}$
 $= -4.99 \times 10^5 \text{ J/g}$

7. What is the partial pressure of carbon dioxide in a container that contains 3.63 mol of oxygen, 1.49 mol of nitrogen, and 4.49 mol of carbon dioxide when the total pressure is 871 mmHg?

- a. 871 mmHg
- b. 135 mmHg
- c. 324 mmHg
- d. 406 mmHg
- e. 763 mmHg

* $P_{CO_2} = ?$
 $n_{tot} = 3.63 + 1.49 + 4.49$
 $= 9.61 \text{ mol}$
 $\Rightarrow X_{CO_2} = \frac{4.49}{9.61} = 0.467$
 $P_{tot} = 871 \text{ mmHg}$
 $\Rightarrow P_{CO_2} = 0.467 \times 871 = 406 \text{ mmHg} \checkmark$

8. Which of the following is/are true of Avogadro's Law?

1. Avogadro's Law relates the volume of a gas to the moles of the gas at constant temperature and pressure.
2. Avogadro's Law states that the pressure of a gas decreases if the volume is increased at constant temperature and molar concentration.
3. Avogadro's Law states that the pressure of a gas increases with the increase in its temperature at constant volume and molar concentration.

- a. 1 and 3
- b. 3 only
- c. 2 only
- d. 1 only
- e. 2 and 3

9. The partial pressures of CH_4 , N_2 and O_2 in a sample of gas were found to be 100 mmHg , 443 mmHg and 693 mmHg respectively. What is the mole fraction of nitrogen?

- a. 0.525
- b. **0.336**
- c. 0.410
- d. 21.7
- e. 0.412

* $P_{\text{CH}_4} = 100 \text{ mmHg}$
 $P_{\text{N}_2} = 443 \text{ mmHg}$
 $P_{\text{O}_2} = 693 \text{ mmHg}$
 $\Rightarrow P_{\text{tot}} = 1319 \text{ mmHg}$
 $\Rightarrow X_{\text{N}_2} = \frac{443}{1319} = 0.336 \checkmark$

10. The volume of a sample of gas measured at 35.0°C and 1.00 atm pressure is 2.00 L . What must the final temperature be in order for the gas to have a final volume of 3.00 L at 1.00 atm pressure?

- a. 52.5°C
- b. **189.0°C**
- c. -220.5°C
- d. 23.3°C
- e. -67.7°C

* $V_i = 2 \text{ L}$
 $T_i = 35^\circ\text{C} = 308 \text{ K}$
 $P_i = 1 \text{ atm}$
 $T_f = ?$
 $V_f = 3 \text{ L}$
 $P_f = 1 \text{ atm}$
 } \rightarrow constant

$\frac{V_i}{T_i} = \frac{V_f}{T_f}$
 $\Rightarrow T_f = \frac{V_f T_i}{V_i} = \frac{3 \times 308}{2} = 462 \text{ K} = 189^\circ\text{C} \checkmark$

11. What is the total number of subshells found in the $n=6$ shell?

- a. 7
- b. 36
- c. 5
- d. **6**
- e. 8

* $n=6 \Rightarrow L = n-1 = 5$
 $L = 0, 1, 2, 3, 4, 5 \Rightarrow 6 \text{ subshells} \checkmark$

12. The reaction of iron with hydrochloric acid is represented by the following thermochemical equation, $\text{Fe}(s) + 2\text{HCl}(aq) \rightarrow \text{FeCl}_2(aq) + \text{H}_2(g)$; $\Delta H = -87.9 \text{ kJ}$. In which of the following experiments would the temperature rise the most?

- a. 1.1 g of Fe added to 1.0 L of 0.02 M HCl
- b. **1.1 g of Fe added to 1.0 L of 0.04 M HCl**
- c. 0.56 g of Fe added to 1.0 L of 0.03 M HCl
- d. 2.2 g of Fe added to 1.0 L of 0.03 M HCl
- e. 4.5 g of Fe added to 1.0 L of 0.03 M HCl

* $\text{Fe} + 2\text{HCl} \rightarrow \text{FeCl}_2 + \text{H}_2 \quad \Delta H = -87.9 \Rightarrow \text{exothermic reaction} \Rightarrow$ رفع درجة حرارة لأنه يفرغ طاقة
 بونا نستوف مشو الكميات من ال Fe وال HCl التي بتعطي عدد مولات اله 2 وبنفس الوقت نعتق النسبة $1:2$ بمعنى إنه يكون عدد مولات ال HCl فنيق عدد مولات ال Fe .

* $M_w(\text{Fe}) = 55.5 \text{ g/mol}$

a) $n_{\text{Fe}} = \frac{1.1 \text{ g}}{55.5 \text{ g/mol}} = 0.02 \text{ mol}$ $n_{\text{HCl}} = 1 \text{ L} \times 0.02 \text{ M} = 0.02 \text{ mol} \Rightarrow \frac{0.02 \text{ Fe}}{0.02 \text{ HCl}} = \frac{1}{1} \times$

b) $n_{\text{Fe}} = \frac{1.1 \text{ g}}{55.5 \text{ g/mol}} = 0.02 \text{ mol}$ $n_{\text{HCl}} = 1 \text{ L} \times 0.04 \text{ M} = 0.04 \text{ mol} \Rightarrow \frac{0.02 \text{ Fe}}{0.04 \text{ HCl}} = \frac{1}{2} \checkmark$

c) $n_{\text{Fe}} = \frac{0.56 \text{ g}}{55.5 \text{ g/mol}} = 0.01 \text{ mol}$ $n_{\text{HCl}} = 1 \times 0.03 \text{ mol} \Rightarrow \frac{0.01 \text{ Fe}}{0.03 \text{ HCl}} = \frac{1}{3} \checkmark$

d) $n_{\text{Fe}} = \frac{2.2 \text{ g}}{55.5 \text{ g/mol}} = 0.04 \text{ mol}$ $n_{\text{HCl}} = 1 \times 0.03 = 0.03 \text{ mol} \Rightarrow \frac{0.04 \text{ Fe}}{0.03 \text{ HCl}} = \frac{4}{3} \times$

e) $n_{\text{Fe}} = \frac{4.5 \text{ g}}{55.5 \text{ g/mol}} = 0.08 \text{ mol}$ $n_{\text{HCl}} = 1 \times 0.03 = 0.03 \text{ mol} \Rightarrow \frac{0.08 \text{ Fe}}{0.03 \text{ HCl}} = \frac{8}{3} \times$

13. Which of the following processes will result in the lowest final temperature of the metal-water mixture at equilibrium? The specific heat of cobalt is 0.421 J/g°C

- a. the addition of 100 g of cobalt at 95°C to 40 ml of water at 25°C in an insulated container
- b. the addition of 100 g of cobalt at 95°C to 80 ml of water at 25°C in an insulated container
- c. **the addition of 100 g of cobalt at 95°C to 100 ml of water at 25°C in an insulated container**
- d. the addition of 100 g of cobalt at 95°C to 60 ml of water at 25°C in an insulated container
- e. the addition of 100 g of cobalt at 95°C to 20 ml of water at 25°C in an insulated container

Addition of 100g of cobalt at 95°C to 100 ml of water at 25°C in an insulated container ✓
 $q = m \cdot s \cdot \Delta T$
 $m \downarrow \Rightarrow \Delta T \uparrow$
 لو فيه نقص في الـ m على masss لكان خياره صح بطلع اقل درجة

14. Under conditions of constant pressure, for which of the following reaction is the magnitude of pressure-volume work going to be greatest?

- a. $2H_2O_2(l) \rightarrow 2H_2O(l) + O_2(g)$
- b. $BaCO_3(s) + SO_3(g) \rightarrow BaSO_4(s)$
- c. $2NO(g) + O_2(g) \rightarrow 2NO_2(g)$
- d. **$2KClO_3(s) \rightarrow 2KCl(s) + 3O_2(g)$**
- e. $H_2(g) + Cl_2(g) \rightarrow 2HCl(g)$

* greater work $\Rightarrow \uparrow \Delta n$
 a $\rightarrow \Delta n = 1$
 b $\rightarrow \Delta n = -1$
 c $\rightarrow \Delta n = -1$
 d $\rightarrow \Delta n = 3$ ✓
 e $\rightarrow \Delta n = 0$

15. If 250 ml of methane, CH₄, effuses through a small hole in 20 s, the time required for the same volume of helium to pass through the hole under the same conditions will be :-

- a. **10 s**
- b. 1.3 s
- c. 40 s
- d. 5 s
- e. 80 s

* $\frac{t_2}{t_1} = \sqrt{\frac{M_2}{M_1}}$
 $\frac{t_2}{20} = \sqrt{\frac{4}{16}}$
 $\frac{t_2}{20} = \frac{1}{2} \Rightarrow t_2 = 10s$ ✓

16. At 530.4 mmHg and 55.3°C, a 3.14-L sample of a hydrocarbon gas has a mass of 2.28 g. What is the formula of the gas?

- a. C₂H₆
- b. C₂H₂
- c. **C₂H₄**
- d. C₃H₆
- e. C₃H₈

* $P = 530.4 \text{ mmHg} = 0.698 \text{ atm}$
 $T = 55.3^\circ\text{C} = 328.3 \text{ K}$
 $V = 3.14 \text{ L}$
 $m = 2.28 \text{ g}$
 formula = ?
 $M_w = \frac{mRT}{PV} = 28 \text{ g/mol}$
 (g) PV (M_w)
 C₂H₆ $\rightarrow 2(4) + 6 = 30 \times$
 C₂H₂ $\rightarrow 2(4) + 2 = 26 \times$
C₂H₄ $\rightarrow 2(4) + 4 = 28$ ✓

17. What is the standard enthalpy change for the following reaction? $N_2H_4(l) + 2NO_2(g) \rightarrow 2N_2O(g) + 2H_2O(l)$

- $N_2H_4(l) \Delta H_f^\circ \text{ (KJ/mol)} + 50.6$
- $NO_2(g) \Delta H_f^\circ \text{ (KJ/mol)} + 33.1$
- $N_2O(g) \Delta H_f^\circ \text{ (KJ/mol)} + 82.1$
- $H_2O(l) \Delta H_f^\circ \text{ (KJ/mol)} - 285.8$

* $N_2H_4 + 2NO_2 \rightarrow 2N_2O + 2H_2O$
 $\downarrow \quad \quad \downarrow \quad \quad \downarrow \quad \quad \downarrow$
 50.6 33.1 82.1 -285.8
 $\Rightarrow \Delta H^\circ = 2(82.1) - 2(285.8) - ((2 \times 33.1) + 50.6) = -524.2 \text{ KJ}$ ✓

- a. -119.7 KJ
- b. +290.6 KJ
- c. **-524.2 KJ**
- d. -290.6 KJ
- e. +119.7 KJ

10. A 500-cm³ sample of 1.0 M NaOH(aq) is added to 500 cm³ of 1.0 M HCl(aq) in a styrofoam cup, and the solution is quickly stirred. The rise in temperature (ΔT_1) is measured. The experiment is repeated using 100 cm³ of each solution, and the rise in temperature (ΔT_2) is measured. What conclusion can you draw about ΔT_1 and ΔT_2 ? $\text{HCl}_{(aq)} + \text{NaOH}_{(aq)} \rightarrow \text{H}_2\text{O}_{(l)} + \text{NaCl}_{(aq)}$; $\Delta H^\circ = -55.8 \text{ kJ}$

- a. ΔT_1 is five times as large as ΔT_2
- b. ΔT_1 is less than ΔT_2
- c. ΔT_2 is greater than ΔT_1
- d. ΔT_2 is equal to ΔT_1
- e. ΔT_2 is five times as large as ΔT_1

$$V_1/T_1 = V_2/T_2$$

$$\Rightarrow \frac{500 + 500}{100 + 100} = \frac{T_1}{T_2}$$

$$\Rightarrow \frac{1000}{200} = \frac{T_1}{T_2} \Rightarrow T_1 = 5T_2$$

ΔT_1 is five times as large as ΔT_2 ✓

19. Absolute zero is the point at which:

- a. a straight-line graph of V versus T(K) intersects the origin.
- b. a straight-line graph of V versus 1/P at constant T intersects the origin.
- c. gaseous helium liquefies.
- d. a straight-line graph of V versus T(°C) intersects the origin.
- e. a straight-line graph of 1/V versus P at constant T intersects the origin.

* Absolute Zero describes Charles's law which relates V and T(K) so it is a **straight line graph of V vs. T(K) intersects the origin** ✓

20. How many values are there for the magnetic quantum number when the value of the angular momentum quantum number is 3?

- a. 7
- b. 14
- c. 15
- d. 1
- e. 12

* Angular momentum quantum number (l) = 3
number of (ml) = 2l + 1 = 7 ✓

21. a small amount wet of hydrogen gas(H₂) can be prepared by the reaction of zinc with excess hydrochloric acid and trapping the gas produced in an inverted tube initially filled with water, if the total pressure of the gas in the collection tube is 757.9 mmHg at 25°C, what is the partial pressure of the hydrogen? The vapor pressure of water is 23.8 mmHg

- a. 731.7 mmHg
- b. 734.1 mmHg
- c. 47.7 mmHg
- d. 32.9 mmHg
- e. 757.9 mmHg

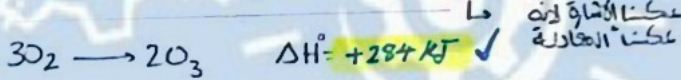
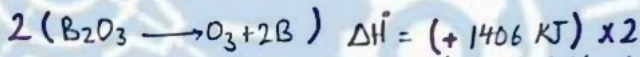
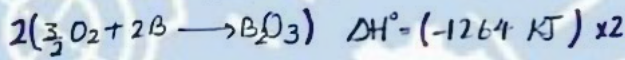
* Zn is the limiting reagent
P_{tot} = 757.9 mmHg
T = 25°C
P_{H₂O} = 23.8 mmHg
P_{H₂} = P_{tot} - P_{H₂O} = 757.9 - 23.8 = 734.1 mmHg ✓

22. Given the following thermochemical data at 25°C and 1 atm pressure, $\frac{3}{2}O_2(g) + 2B(s) \rightarrow B_2O_3(s)$; $\Delta H^\circ = -1264 \text{ kJ}$; $O_3(g) + 2B(s) \rightarrow B_2O_3(s)$; $\Delta H^\circ = -1406 \text{ kJ}$; determine ΔH° for the following reaction at 25°C and 1 atm pressure.



- a. +980 kJ/mol
- b. **+284 kJ/mol**
- c. -234 kJ/mol
- d. -980 kJ/mol
- e. -2670 kJ/mol

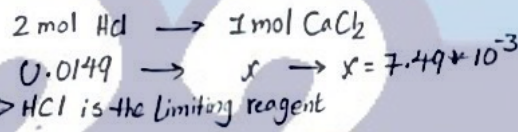
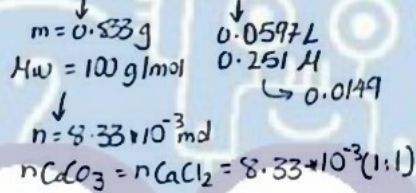
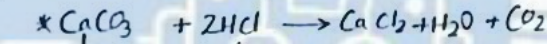
* ΔH° for $3O_2 \rightarrow 2O_3$



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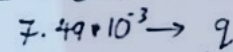
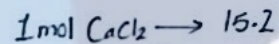
23. How much heat is liberated at constant pressure if 0.833 g of calcium carbonate reacts with 59.7 ml of 0.251 M hydrochloric acid? $CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$; $\Delta H^\circ = -15.2 \text{ kJ}$.

- a. **0.113 kJ**
- b. 0.526 kJ
- c. 3.81 kJ
- d. 12.6 kJ
- e. 0.24 kJ



$\Delta H^\circ = -15.2$

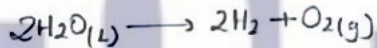
$$q = -\Delta H$$



$$\rightarrow q = 15.2 \times 7.49 \times 10^{-3} = 0.113 \text{ kJ} \quad \checkmark$$

24. Which of the following statements is true concerning the decomposition of liquid water to form hydrogen gas and oxygen gas? $2H_2O(l) \rightarrow 2H_2(g) + O_2(g)$

- a. **ΔH is greater than ΔU because of the pressure-volume work done by the gaseous products.**
- b. ΔH is less than ΔU because the atmosphere does pressure-volume work on the gaseous products.
- c. ΔH is less than ΔU because of the pressure-volume work done by the gaseous products.
- d. ΔH is greater than ΔU because the pressure is constant.
- e. ΔH is equal to ΔU because both are state functions.



$$\Delta H = \Delta U + P\Delta V \rightarrow \text{work}$$

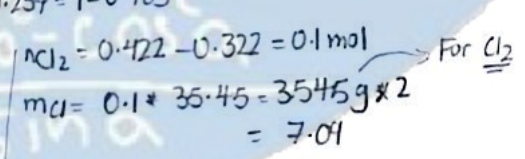
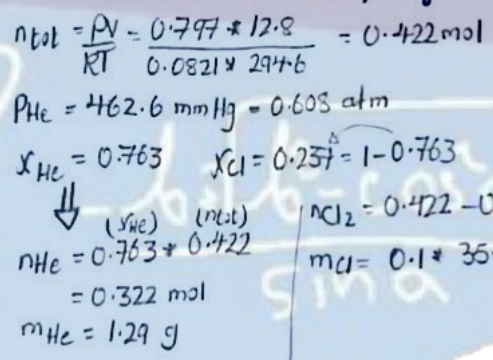
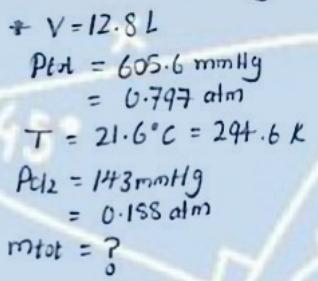
$$\Delta H = \Delta U + \text{work}$$

$$\Delta H > \Delta U \quad \text{so} \quad \Delta H \text{ is greater than } \Delta U \text{ because of the pressure-volume work done by gaseous products.} \quad \checkmark$$

* نلاحظ ان H_2O سائل و H_2, O_2 غازين
 وبجهاؤول (pressure) وبالتالي الجهد (القانون كالتالي) * [زيادة]

25. In a mixture of helium and chlorine, occupying a volume of 12.8 L at 605.6 mmHg and 21.6°C, it is found that the partial pressure of chlorine is 143 mmHg. What is the total mass of the sample?

- 31.6 g
- 7.09 g
- 1.28 g
- 0.4 g
- 8.37 g**



$$\Rightarrow m_{\text{tot}} = m_{He} + m_{Cl_2} = 1.29 + 7.09 = 8.37 \text{ g} \quad \checkmark$$

Good Luck :)