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

* $V_{N_2} = 0.636$ L
$P = 488.9$ mmHg $\times \frac{1 atm}{760 mmHg} = 0.643$ atm
$T = 22.3°C = 22.3 + 273 = 295.3$ K
$m_{NI_3} = ?$

$N_2 + 3I_2 \rightarrow 2NI_3$ (N_2: Limiting reactant; I_2: excess بزيادة)

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

$n_{N_2} = 0.01687$ mol

1 mol $N_2 \rightarrow$ 2 mol NI_3
0.01687 mol $\rightarrow \frac{m}{394.72 g/mol}$ $\Rightarrow m = 2 \times 0.01687 \times 394.72$
= **13.3 g** ✓

2. How much heat is evolved upon the complete oxidation of 6 g 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. 85.59 KJ
b. **186 KJ**
c. 342.3 KJ
d. 684.7 KJ
e. 9.233×10^3 KJ

* $4Al + 3O_2 \rightarrow 2Al_2O_3$
$n_{Al} = \frac{6 g}{27 g/mol} = 0.222$ mol
$n_{Al_2O_3} = \frac{1}{2} n_{Al} = 0.111$ mol
heat evolved (q) $= -\Delta H \times n_{Al_2O_3}$
$= 1676 \times 0.111$
$=$ **186 KJ** ✓

3. A 86.9-g sample of Chromium ($s = 0.447$ J/(g·°C)), initially at 338.33°C, is added to an insulated vessel containing 189.9 g of water ($s = 4.18$ J/(g·°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 KJ/°C.

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

* for chromium: $m = 86.9$ g, $s = 0.447$ J/(g·°C), $t_i = 338.33$°C, $t_f = 28.06$°C
$\Rightarrow q_{cr} = ms\Delta t = 86.9 \times 0.447 \times (28.06 - 338.33) = -12052 J = -12.052$ KJ

* The vessel: $C = 0.22$ KJ/°C, $t_i = 16.17$°C, $t_f = 28.06$°C
$\Rightarrow q_{vessel} = C\Delta t = 0.22 \times (28.06 - 16.17) = 2.616$ KJ

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

$-q_{cr} = q_{vessel} + q_{H_2O} \Rightarrow q_{H_2O} = -q_{cr} - q_{vessel}$
$= -(-12.052) - 2.616$
$=$ **9.436 KJ** ✓ → 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 mol $SO_3 \rightarrow$ 4 mol atoms
1 mol He $\rightarrow$ 1 mol atoms ($n \propto V$)

$\Rightarrow$ 4 mol He $\rightarrow$ 1 mol SO_3
4 L He $\rightarrow V_{SO_3}$ $\Rightarrow V_{SO_3} = \frac{4}{4} =$ **1 L** ✓

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. $H_{2(g)} + I_{2(s)} \rightarrow 2HI_{(s)}, \Delta H^\circ = 73.8$ KJ
b. $H_{2(g)} + I_{2(s)} \rightarrow 2HI_{(s)}, \Delta H^\circ = -36.9$ KJ
c. $H_{2(g)} + I_{2(s)} \rightarrow 2HI_{(s)}, \Delta H^\circ = 36.9$ KJ
d. $H_{2(g)} + I_{2(s)} \rightarrow 2HI_{(s)}, \Delta H^\circ = -52.72$ KJ
e. **$H_{2(g)} + I_{2(s)} \rightarrow 2HI_{(s)}, \Delta H^\circ = 52.72$ KJ**

* $n_{H_2} = 0.7$ mol
$n_{I_2} = 0.7$ mol
$P = 1$ atm
$m_{HI} = 1.4$ mol
$q = +36.9$ KJ
absorbs heat ⇒ endothermic ⇒ $\Delta H = +ve$
$H_2 + I_2 \rightarrow 2HI$
1.4 mol HI → 36.9
2 mol HI → ΔH
$\Rightarrow \Delta H^\circ = \frac{36.9 * 2}{1.4} = 52.72$ KJ ✓

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. $-2.33 * 10^3$ J/g
b. -0.560 J/g
c. **$-4.99 * 10^5$ J/g**
d. -5.29 J/g
e. -0.120 J/g

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

0.106 g → −5.29 KJ
1 g → x ⇒ $x = \frac{-5.29 \text{ KJ}}{0.106 \text{ g}}$
$= -49.9$ KJ/g
$= -4.99 * 10^5$ 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. 329 mmHg
d. **406 mmHg**
e. 763 mmHg

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

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 increase 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 183 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

* $P_{CH_4} = 183$ mmHg
$P_{N_2} = 443$ mmHg
$P_{O_2} = 693$ mmHg
$\Rightarrow P_{tot} = 1319$ mmHg
$\Rightarrow X_{N_2} = \frac{443}{1319} = 0.336$ ✓

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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 temprature 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

* $V_i = 2L$
$T_i = 35°C = 308 K$
$P_i = 1$ atm
$T_f = ?$
$V_f = 3L$
$P_f = 1$ atm
(Pi, Pf) → constant

$\frac{V_i}{T_i} = \frac{V_f}{T_f}$

$\Rightarrow T_f = \frac{V_f T_i}{V_i} = \frac{3 \times 308}{2} = 462 K = 189°C$ ✓

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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 subshells ✓

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12. The reaction of iron with hydrochloric acid is represented by the following thermochemical equation,
$Fe_{(s)} + 2HCl_{(aq)} \rightarrow FeCl_{2(aq)} + H_{2(g)}$; $\Delta H = -87.9$ KJ; In which of the following experiments would the temprelure 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

* $Fe + 2HCl \rightarrow FeCl_2 + H_2$ $\Delta H = -87.9 \Rightarrow$ exothermic reaction ⇒ فيع درجة حرارة لانه يعطي طاقة

بدنا نشوف شو الكميات من الـ Fe والـ HCl الي تعطي عدد مولات الاهم الـ ⇐ وبنفس الوقت تحقق النسبة 1:2 بمعنى انه يكون عدد مولات الـ HCl ضعف عدد مولات الـ Fe.

* $Mw(Fe) = 55.5$ g/mol.

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

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

c) $n_{Fe} = \frac{0.56 g}{55.5 g/mol} = 0.01 mol$ $n_{HCl} = 1 \times 0.02 mol \Rightarrow \frac{0.01 Fe}{0.02 HCl} = \frac{1}{2}$ ✓

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

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

الكل يا طيا يا اخترنا لانه فيه اكبر عدد مولات ومحقق النسبة برضوت

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13. Which of the following processes will result in the lowest final tempreture of the metal-water mixture at equilibruim? 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 100 g of cobalt at 95°C to 100 ml of water at 25°C in an insulated container ✓

$q = ms\Delta t$, $\Delta t = t_f - t_i$

$m\downarrow \Rightarrow \Delta t_f \uparrow$

لو نجرب نقسم ال (q) على mass×s لكل خيار منطرح نطلع أول قيمة ي

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. $BaO_{(s)} + SO_{3(g)} \rightarrow BaSO_{4(s)}$
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, CH_4, 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

$$\frac{t_2}{t_1} = \sqrt{\frac{M_2}{M_1}}$$

$$\frac{t_2}{t_1} = \sqrt{\frac{4}{16}}$$

$$\frac{t_2}{20} = \frac{1}{2} \Rightarrow t_2 = 10\,s$$ ✓

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. C_2H_6
b. C_2H_2
c. C_2H_4
d. C_3H_6
e. C_3H_8

* P = 530.4 mmHg = 0.698 atm
T = 55.3°C = 328.3 K
V = 3.14 L
m = 2.28 g
formula = ?

$M_w = \frac{mRT}{PV} = 28\ g/mol$

(gas) — (M_w)
$C_2H_6 \rightarrow 24 + 6 = 30$ ✗
$C_2H_2 \rightarrow 24 + 2 = 26$ ✗
$C_2H_4 \rightarrow 24 + 4 = 28$ ✓

17. What is the standard enthalpy change for the following reaction? $N_2H_{4(l)} + 2NO_{2(g)} \rightarrow 2N_2O_{(g)} + 2H_2O_{(l)}$

$N_2H_{4(l)}$ $\Delta H^\circ f$ (KJ/mol) +50.6
$NO_{2(g)}$ $\Delta H^\circ f$ (KJ/mol) +33.1
$N_2O_{(g)}$ $\Delta H^\circ f$ (KJ/mol) +82.1
$H_2O_{(l)}$ $\Delta H^\circ f$ (KJ/mol) −285.8

* $N_2H_4 + 2NO_2 \rightarrow 2N_2O + 2H_2O$
(50.6) (33.1) (82.1) (−285.8)

$\Rightarrow \Delta H^\circ = 2(82.1) - 2(285.8) - ((2 \times 33.1) + 50.6) = -524.2\ KJ$ ✓

a. −119.7 KJ
b. +290.6 KJ
c. −524.2 KJ
d. −290.6 KJ
e. +119.7 KJ

18. A 500-cm^3 sample of 1.0 M $NaOH_{(aq)}$ is added to 500 cm^3 of 1.0 M $HCl_{(aq)}$ in a styrofoam cup, and the solution is quickly stirred. The rise in temprature (ΔT_1) is measured. The experiment is repeated using 100 cm^3 of each solution, and the rise in tempreture (ΔT_2) is measured. What conclusion can you draw about ΔT_1 and ΔT_2? $HCl_{(aq)} + NaOH_{(aq)} \rightarrow H_2O_{(l)} + NaCl_{(aq)}$; $\Delta H° = -55.8$ kJ

a. ΔT_1 is five times as larg 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 larg as ΔT_1

$V_1/T_1 = V_2/T_2$

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

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

$\Rightarrow$ ΔT_1 is five times as larg as T_2 ✓

19. Absolute zero in 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 Charle'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 these for the magnetic quantum number when the value of the angular momentum quantum number is 3?

* Angular momentum quantum number (l) = 3

number of (ml) = 2(l)+1 = 7 ✓

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

21. a small amount wet of hydrogen gas(H_2) 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. 32.8 mmHg
e. 757.9 mmHg

* Zn is the limiting reagent

$P_{tot} = 757.9$ mmHg

T = 25°C

$P_{H_2O} = 23.8$ mmHg

$P_{H_2} = P_{tot} - P_{H_2O} = 757.9 - 23.8 = 734.1$ mmHg ✓

22. Given the following thermochemical data at 25C and 1 atm pressure, $\frac{3}{2}O_{2(g)} + 2B_{(s)} \rightarrow B_2O_{3(s)}$; $\Delta H = -1264$ KJ ; $O_{3(g)} + 2B_{(s)} \rightarrow B_2O_{3(s)}$; $\Delta H° = -1406$ KJ; determine $\Delta H°$ for the following reaction at 25°C and 1 atm pressure.
$3O_{2(g)} \rightarrow 2O_{3(g)}$

a. +980 KJ/mol
b. **+284 KJ/mol**
c. −284 KJ/mol
d. −980 KJ/mol
e. −2670 KJ/mol

* $\Delta H°$ for $3O_2 \rightarrow 2O_3$

$2(\frac{3}{2}O_2 + 2B \rightarrow B_2O_3)$ $\Delta H° = (-1264$ KJ$) \times 2$

$2(B_2O_3 \rightarrow O_3 + 2B)$ $\Delta H° = (+1406$ KJ$) \times 2$ ← عكسنا الإشارة لأن عكسنا المعادلة

$3O_2 \rightarrow 2O_3$ $\Delta H° = +284$ KJ ✓

23. How much heat is librated at constant pressure if 0.833 g of calcuim carbonate reacts with 59.7 mL of 0.251 M hydrochloric acid? $CaCO_{3(s)} + 2HCl_{(aq)} \rightarrow CaCl_{2(aq)} + H_2O_{(L)} + CO_{2(g)}$; $\Delta H° = -15.2$ KJ.

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

* $CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$

$CaCO_3$: m = 0.833 g, Mw = 100 g/mol → $n = 8.33 \times 10^{-3}$ mol

HCl: 0.0597 L, 0.251 M → 0.0149

$nCaCO_3 = nCaCl_2 = 8.33 \times 10^{-3}$ (1:1)

2 mol HCl → 1 mol $CaCl_2$
0.0149 → x → $x = 7.49 \times 10^{-3}$

⟹ HCl is the Limiting reagent

$\Delta H° = -15.2$
$q = -\Delta H$

1 mol $CaCl_2$ → 15.2
7.49×10^{-3} → q

→ $q = 15.2 \times 7.49 \times 10^{-3}$
$= 0.113$ KJ ✓

24. Which of the following statments is true concerning the decompostion 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 ΔU because both are state functions.

$2H_2O_{(L)} \rightarrow 2H_2 + O_{2(g)}$

* نلاحظ ان H_2O كان Liquid وبعدها تحول لغازين H_2, O_2 وبالتالي الضغط (pressure) رح يزداد

* القانون كالتالي ←

$\Delta H = \Delta U + P\Delta V$ → work, → P↑

$\Delta H = \Delta U$ + work

$\Delta H > \Delta U$ so ΔH is greater than ΔU because of the pressure-volume work done by gaseous products. ✓

25. In a mixture of helium and Chlorine, occuping 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?

a. 31.6 g
b. 7.09 g
c. 1.29 g
d. 0.4 g
e. **8.37 g**

* V = 12.8 L
P_{tot} = 605.6 mmHg = 0.797 atm
T = 21.6°C = 294.6 K
P_{Cl_2} = 143 mmHg = 0.188 atm
m_{tot} = ?

$n_{tot} = \frac{PV}{RT} = \frac{0.797 \times 12.8}{0.0821 \times 294.6} = 0.422$ mol

P_{He} = 462.6 mmHg = 0.608 atm

$X_{He} = 0.763$ $X_{Cl} = 0.237 = 1 - 0.763$

⇓

$n_{He} = 0.763 \times 0.422$ (X_{He})(n_{tot})
$= 0.322$ mol
$m_{He} = 1.29$ g

$nCl_2 = 0.422 - 0.322 = 0.1$ mol
$m_{Cl} = 0.1 \times 35.45 = 3.545$ g $\times 2$ → For Cl_2
$= 7.09$

⇒ $m_{tot} = m_{He} + m_{Cl_2}$
$= 1.29 + 7.09 = 8.37$ g ✓

Good Luck :)