University of Bahrain, Department of Chemistry
Chemy 102, Second Semester 2012-2013
1st hour examination _____/35

Time : 75 min, Examiners: Dr. Layla Saleem, Dr. Ahmad Saad & Reema Balachandra

Name ..... Key ..... ID ..... Sec .....

The relative energies of molecular orbitals:

$H_2 - N_2$:

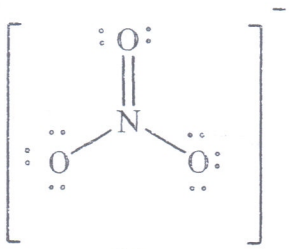
$$\sigma_{1s} < \sigma^*_{1s} < \sigma_{2s} < \sigma^*_{2s} < \pi_{2p_y} = \pi_{2p_z} < \sigma_{2p_x} < \pi^*_{2p_y} = \pi^*_{2p_z} < \sigma^*_{2p_x}$$

O_2 *and* F_2 :

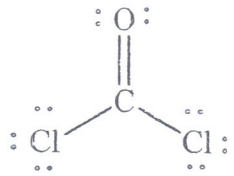
$$\sigma_{1s} < \sigma^*_{1s} < \sigma_{2s} < \sigma^*_{2s} < \sigma_{2p_x} < \pi_{2p_y} = \pi_{2p_z} < \pi^*_{2p_y} = \pi^*_{2p_z} < \sigma^*_{2p_x}$$

$H = E + PV$
$\Delta E = q + w$
R = 0.0821 L.atm/mol.K
= 8.314 J K^{-1} mol^{-1}
1L · atm = 101.3 J
specific heat of water = 4.18 J/g·°C

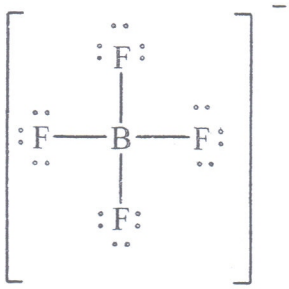
Q1 *(5 marks)*



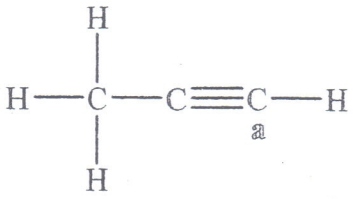
(a)



(b)



(c)



(d)

(i) The geometry of (a) is ---Triangular Planar---

(ii) The geometry of (c) is ---Tetrahedral---

(iii) The hybridization on **N** in (a) is ---sp^2---

(iv) The hybridization on **C a** in (d) is ---sp---

(v) The **FBF** bond angle in (c) is ---$109.5°$---

(vi) The **OCCl** bond angle in (b) is ---$120°$---

(vii) The polar structure(s) is/are ---b & d---

(viii) The formal charge on **C** in (b) is ---C---

(ix) The number of resonance structures in (a) is/are ---3---

(x) The total number of π bonds in all structures is ---4---

Q2 *(3 marks)*

The molecular orbital electron configuration of a homonuclear diatomic molecule is :

$(\sigma_{1s})^2\ (\sigma^*_{1s})^2\ (\sigma_{2s})^2\ (\sigma^*_{2s})^2\ (\sigma_{2p_x})^2\ (\pi_{2p_y})^2\ (\pi_{2p_z})^2\ (\pi^*_{2p_y})^2\ (\pi^*_{2p_z})^2$

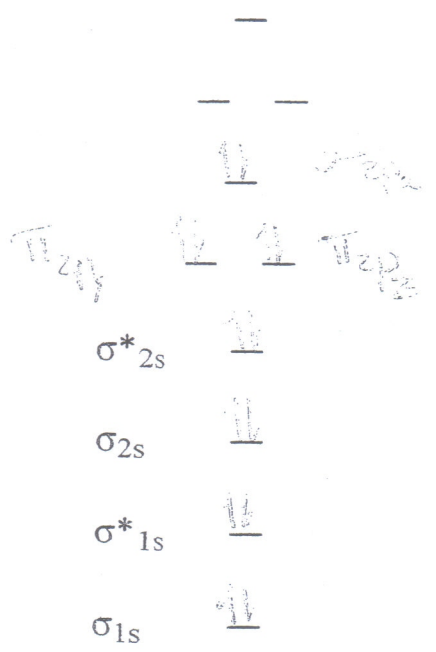
A) What is the molecule? ....F_2....

B) What is the bond order of the molecule ? ....1....

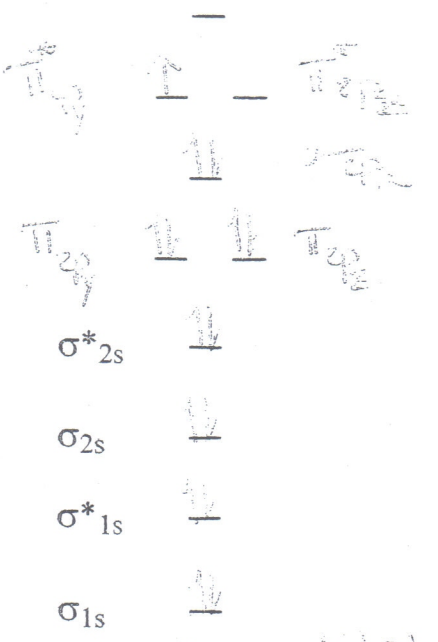
C) Is the molecule stable? ....Yes....

Q3 *(6 marks)*

A) Complete the electron configuration of N_2 and N_2^- and give the missing names of the orbitals:



N_2



N_2^-

B) Which one is more stable? ..N_2..

C) Which one has longer bond length? ..N_2^-..

D) Which one(s) is/are paramagnetic? ..N_2^-..

Q4 *(2 marks)*

Heat of 26 J is given off to the surrounding when 74 J of work was done to compress a gas. Calculate the change in energy of the gas.

$\Delta E = (-26 + 74)$ J

$\Delta E =$ 48 J

Q5 *(1 mark)*

Consider the reaction :

$$H_2(g) + Cl_2(g) \rightarrow 2\,HCl(g) \qquad \Delta H = -184.6\ kJ/mol$$

What is ΔE for this reaction if 3 moles of H_2 react with 3 moles of Cl_2 at 25°C to form HCl ?

a) -184.6 kJ/mol b) 184.6 kJ/mol c) -553.8 kJ/mol
d) 553.8 kJ/mol e) 0 kJ/mol

Q6 *(2 marks)*

Consider the following reaction :

$$2\,NO(g) + O_2(g) \rightarrow 2\,NO_2(g) \qquad \Delta H = -114.6\ kJ/mol$$

Calculate the amount of heat given off when 1.26×10^2 g of NO_2 are produced.

$\Delta H =$ -157 kJ

Q7 *(1 mark)*

A coffee-cup calorimeter contains 10.0 g of water at 59.00°C. If 3.00 g Au at 15.20°C is placed in the calorimeter, what is the final temperature of the water in the calorimeter? The specific heat of water is 4.184 J/g·°C; the specific heat of gold is 0.128 J/g·°C.

a. 55.37°C b. 58.60°C c. 59.40°C d. 60.80°C
e. 64.19°C

Q8 (show your work) **(3 marks)**

One gram of acetylene releases 48.2 kJ. When 0.750 g of acetylene is burned in a bomb calorimeter (heat capacity = 1.117 kJ/°C), the final temperature of the bomb is 54.5°C. What is the initial temperature of the calorimeter ?

(1pt) ΔH 1g of $C_2H_2 \longrightarrow -48.2$ kJ

0.750g " $\longrightarrow$? $\longrightarrow -36.15$ kJ

(1pt) $q = -C_{cal}\,\Delta t$

$-36.15\ kJ = -1.117\ \frac{kJ}{°C}(54.5 - t_i)°C$

(1pt) $\therefore t_i = 32.1°C$

Q9 **(1 marks)**

What is the **molar** heat of combustion of benzene, C_6H_6 , if combustion of 1.00 g of benzene causes a temperature rise of 5.18°C in a bomb calorimeter that has a heat capacity of 8.07 kJ/°C?

(a) -41.8 kJ/mol
(b) -3260 kJ/mol
(c) -4180 kJ/mol
(d) -41800 kJ/mol
(e) -48700 kJ/mol

Q10 **(1 mark)**

500 mL of 1.0 M NaOH(aq) are added to 500 mL of 1.0 M HCl(aq) in a coffee cup calorimeter, and the solution is quickly stirred. The rise in temperature (ΔT_1) is measured. The experiment is repeated using 100 mL of each solution, and the rise in temperature (ΔT_2) is measured. It is found that :

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

Q11(show your work) ***(4 marks)***

Determine the heat of reaction for the oxidation of iron,

$$2Fe(s) + 3/2O_2(g) \rightarrow Fe_2O_3(s)$$

given the following thermochemical equations:

1. $2Fe(s) + 6H_2O(l) \rightarrow 2Fe(OH)_3(s) + 3H_2(g)$ $\Delta H = 321.8$ kJ
2. $Fe_2O_3(s) + 3H_2O(l) \rightarrow 2Fe(OH)_3(s)$ $\Delta H = 288.6$ kJ
3. $2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$ $\Delta H = -571.7$ kJ

(1pt) Reverse eq(2) : $2Fe(OH)_3 \rightarrow Fe_2O_3 + 3H_2O$ $\Delta H = -288.6$ kJ

(1pt) eq(3) x 3/2 : $3H_2 + 3/2 O_2 \rightarrow 3H_2O$ $\Delta H = -857.55$ kJ

(1pt) add eq(1) : $2Fe + 6H_2O \rightarrow 2Fe(OH)_3 + 3H_2$ $\Delta H = 321.8$ kJ

(1pt) $2Fe + 3/2 O_2 \rightarrow Fe_2O_3$ $\Delta H = -824.35$ kJ

Q12 (show your work) *(3 marks)*

Ammonium perchlorate can decompose according to the thermochemical equation below.

$$2NH_4ClO_4(s) \rightarrow N_2(g) + Cl_2(g) + 2O_2(g) + 4H_2O(g) \quad \Delta H^o = -375.6 \text{ kJ}$$

The enthalpy of formation of $H_2O(g)$ is -241.8 kJ. Calculate the enthalpy of formation of ammonium perchlorate.

$$\Delta H^\circ_{rxn} = \sum \Delta H^\circ_f(P) - \sum \Delta H^\circ_f(R)$$

$$= \left[\Delta H^\circ_f(N_2) + \Delta H^\circ_f(Cl_2) + 2\Delta H^\circ_f(O_2) + 4\Delta H^\circ_f(H_2O)\right] - \left[2\Delta H^\circ_f(NH_4ClO_4)\right]$$

$$-375.6\text{kJ} = \left[4(-241.8\text{kJ})\right] - \left[2\Delta H^\circ_f NH_4ClO_4\right]$$

$$2\Delta H^\circ_f(NH_4ClO_4) = (+967.2 + 375.6)\text{kJ} = -591.6\text{kJ}$$

$$\therefore \Delta H^\circ_f(NH_4ClO_4) = \frac{-591.6}{2} = -295.8\text{kJ/mol}$$

Q13 Given the following reaction :

$$2\ H_2S(g) + 3\ O_2(g) \rightarrow 2\ SO_2(g) + 2\ H_2O(g)$$

Determine ΔH^o for the above reaction, given the following values : *(1 mark)*

(A) $\Delta H^o_f(H_2S_{(g)}) = -20.6$kJ/mol $\quad\quad$ $\Delta H^o_f(SO_{2(g)}) = -296.8$kJ/mol

$\Delta H^o_f(H_2O_{(g)}) = -241.8$ kJ/mol

(a) -518.0 kJ
(b) +1036.0 kJ
(c) -1036.0 kJ
(d) +518.0 kJ
(e) -6201 kJ

(B) Calculate ΔE at 25°C. **(Show your work)** *(2 marks)*

$$\Delta E = \Delta H^\circ + RT(\Delta n) \qquad \Delta n = 4 - 5 = -1$$

$$= -1036\text{ kJ/mol} + \left(8.314\frac{\text{J}}{\text{K·mol}}\right)(298\text{K})(-1)$$

$$= -1038774\text{ J}$$

$$= -1038.5\text{ kJ}$$