University of Bahrain, Department of Chemistry
Chemy 102, Summer Semester 2012-2013
1st hour examination
Time : 75 min, Examiner: Dr. Ali Hussain

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:

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

Specific heat of water = 4.18 J/g·°C

Q1.

(6 marks)

Consider the following species: O_2^+, O_2^-, and O_2^{2-}

a) What is the bond orders of O_2^+ ? 2.5

b) What is the bond order of O_2^{2-} ? 1

c) Which one is more stable? O_2^+

d) Assign magnetic properties to the species.

O_2^+: paramagnetic O_2^-: paramagnetic O_2^{2-}: diamagnet

e) Assign the following bond distances (in pm) to the corresponding species:

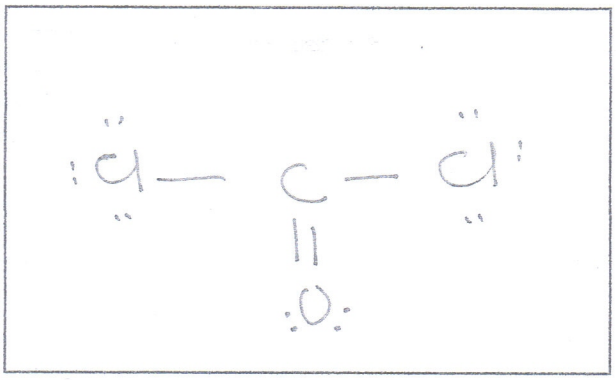
149 ⟶ O_2^{2-}

134 ⟶ O_2^-

112 ⟶ O_2^+

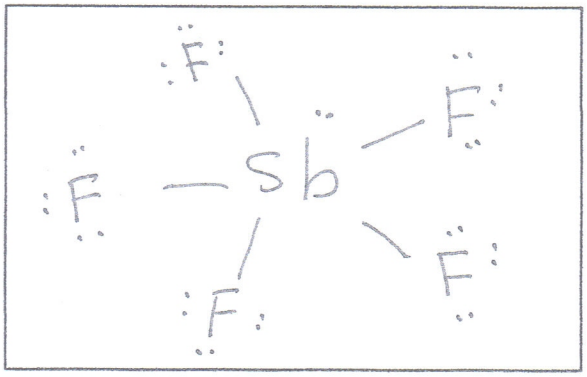
Q2. (2 marks)

Draw Lewis structure for $COCl_2$



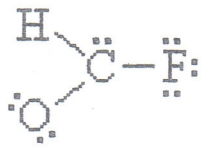
Q3. (2 marks)

Draw Lewis structure for SbF_5^{2-}



Q4. (3 marks)

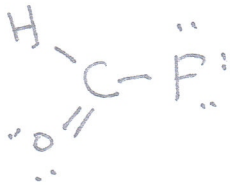
Consider the Lewis structure for HFCO :



(A)

Suggest a better structure and give your reasons.
(keep positions of atoms the same)

(B)



1- octet rule is obeyed by all atoms in (B) (except H)

2- formal charges is zero for all atoms in (B)

3- formal charge on O in A is +1 and on C is -1 although O is more electronegative.

Q6. (3 marks)

1.00 g of sucrose (table sugar, $C_{12}H_{22}O_{11}$) was burned in a bomb calorimeter. The calorimeter had a bomb with a heat capacity of 547 J/°C and a 775 g water reservoir. If the temperature rose from 25.00 to 29.35 °C, what is the heat evolved per mole of sucrose? *(show your work)*

$q_{rxn} = -(q_{bomb} + q_{water})$

$= -(C_{cal}\Delta T + m_w C_w \Delta t)$

$= -(547\ J/°C * 4.35°C + 775g \times 4.18 \frac{J}{g \cdot °C} \times 4.35°C)$

$= -(2379.45 + 14091.8)\ J$

$\therefore q_{rxn} = -16.47\ kJ$

$q_{per\ mol} = \frac{-16.47\ kJ}{(1.00\ g / 342.3\ g\ mol^{-1})} = -5638\ \frac{kJ}{mol}$

$(-5.64 \times 10^3\ \frac{kJ}{mol})$

2.9×10^{-3}

Q7. *(2 marks)*

How much heat is evolved in the reaction of 2.50 g of Fe_2O_3 with enough carbon monoxide to produce iron metal and CO_2 (g)? The equation of the reaction is

$Fe_2O_3\ (s) + 3CO\ (g) \rightarrow 2Fe\ (s) + 3CO_2\ (g) \quad \Delta H° = -24.8\ kJ$

a) 0.555 kJ (b) 0.388 kJ c) 2.58 kJ d) 1.58×10^3 kJ e) 16.1 kJ

Q8. *(2 marks)*

Given:

$2CH_3CH_2OH\ (l) + O_2\ (g) \rightarrow 2CH_3CHO\ (g) + 2H_2O\ (l) \quad \Delta H° = -348.4\ kJ$

$CH_3CO_2H\ (l) \rightarrow CH_3CHO\ (g) + 1/2O_2\ (g) \quad \Delta H° = +318.4\ kJ$

Calculate $\Delta H°$ for

$CH_3CH_2OH\ (l) + O_2\ (g) \rightarrow CH_3CO_2H\ (l) + H_2O\ (l)$

a) 144.2 kJ b) – 144.2 kJ c) – 1015 kJ (d) – 492.6 kJ e) – 507.6 kJ

Q9. *(2 marks)*

Given the following reactions,

$N_2H_4\ (l) + O_2\ (g) \rightarrow N_2\ (g) + 2H_2O\ (g)$ $\quad \Delta H^\circ = -534.2$ kJ

$H_2\ (g) + 1/2\ O_2\ (g) \rightarrow H_2O\ (g)$ $\quad \Delta H^\circ = -241.8$ kJ

Calculate the heat of formation of N_2H_4 . | 50.6 kJ/mol |

Q10.

(show your work) *(3 marks)*

Consider the reaction $H_2O\ (g) \rightarrow H_2\ (g) + \frac{1}{2}\ O_2\ (g)$ $\quad \Delta H^\circ = 241.8$ kJ/mol

If 2 moles of $H_2O\ (g)$ are converted to $H_2\ (g)$ and $O_2\ (g)$ at 125 °C, what is ΔH and ΔE for this reaction?

$2H_2O(g) \longrightarrow 2H_2(g) + O_2(g) \quad \Delta H^\circ = 483.6 \frac{kJ}{mol}$

$H = E + PV \Rightarrow \Delta H = \Delta E + \Delta PV = \Delta E + \Delta n_g RT$

$\therefore \Delta E = \Delta H - RT\Delta n_g \qquad \Delta n_g = +1$

$= 483.6 \frac{kJ}{mol} - 8.314 \frac{J}{K \cdot mol} \cdot \frac{1\ kJ}{10^3\ J} \times 398.15\ K \cdot (+1)$

$= 483.6 \frac{kJ}{mol} - 3.31 \frac{kJ}{mol}$

$= 480 \frac{kJ}{mol}$