University of Bahrain, Department of Chemistry
Chemy 102, First Semester 2013-2014
1st hour examination
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Time : 75 min

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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)

a) Write molecular orbital configuration for N_2^- .

σ^*_{1s} —

σ_{1s} —

b) What is the bond order in N_2^- ? 2.5

c) Is N_2^- paramagnetic or diamagnetic? paramagnetic

d) Which one is more stable N_2^- or N_2 ? N_2

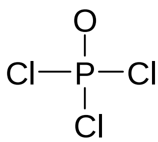
e) Which has the shortest bond length N_2^- or N_2 ? N_2

Q2. (2 marks).

Draw Lewis structure for PCl_4^+ .

4 single bonds and no lone pairs on P

Q3. (4 marks)

$POCl_3$ has the skeleton structure 

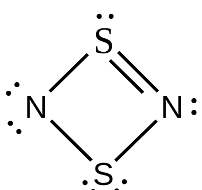
a) Write a Lewis structure following the octet rule.

4 single bonds and no lone pairs on P

b) Write a Lewis structure in which all the formal charges are zero.

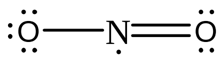
3single P – Cl bonds & double bond between P and O, and no lone pairs on P

Q4. (2 marks)

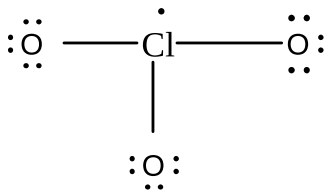
Draw all resonance structures for 

Q5. (7 marks)

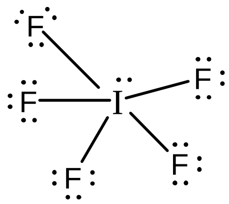
Consider the following Lewis structures



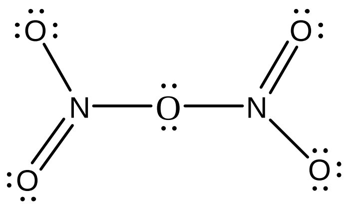
(a)



(b)



(c)



(d)

i) What is the molecular geometry of (a)? bent

ii) What is the molecular geometry of (c)? square pyramid

iii) What is the molecular geometry around N atom in (d)? trigonal planar

iv) What is/are the bond angle(s) in (c)? ~ 90 and 180^o

v) What is/are the bond angle(s) in (d)? ~ 109 and 120 ^{o}

vi) What is the formal charge on N atom in (a)? +1

vii) What is the formal charge on Cl atom in (b)? +3

viii) What is the hybridization on I in (c)? sp^3d^2

ix) What is the hybridization on central O in (d)? sp^3

x) What are the polar structures? a , b, c , d

xi) The octet rule is not followed in a , b, c

xii) How many π bonds are there in (d)? 2

xiii) How many σ bonds are there in (a)? 2

Q6. (2 marks)

NH_4NO_3 absorbs 330 J of heat per gram dissolved in water. In a coffee-cup calorimeter, 4.00 g of NH_4NO_3 is dissolved in 75.0 g H_2O. Assuming that all the heat is lost from the water (c = 4.18 J/g·°C), what is the temperature change of the water? *(show your work)*

Heat released by 4.00 g NH_4NO_3 = 4.00 g × (330 J/g) = 1320 J

= heat released by water = m × c × ΔT

$\therefore$ ΔT = 1320 J / (75.0 g × 4.18 J/g·°C) = 4.21 ^{o}C

Q7. (3 marks)

When 2.00 g of salicylic acid, $C_7H_6O_3$, burns in a bomb calorimeter, the temperature rises by 10.6 ^{o}C. The temperature in the bomb calorimeter increases by 2.68 ^{o}C when the calorimeter absorbs 9.37 kJ. How much heat is given off when one mole of salicylic acid is burned? *(show your work)*

C_{cal} = q / ΔT = 9.37 kJ / 2.68 ^{o}C = 3.50 kJ/ ^{o}C

$q_{reaction}$ (per 2.00 g of salicylic acid) = – q_{cal} = – C_{cal} × ΔT

= – 3.50 kJ/ ^{o}C × 10.6 ^{o}C =

– 37.1 kJ

$q_{reaction}$ (per mol of salicylic acid) = – (37.1 kJ / 2.00 g) × (138.1 g/mol)

= – 2.56×10^3 kJ/mol