# CHEMISTRY 121

**FALL 2011**

**Term Test #3**

**Friday, November 18**

**Name**_____

**Student Number**_____

**Signature**_____

**Section:** **McNeil / Neeland**

## DO NOT TURN THE PAGE UNTIL INSTRUCTED TO DO SO!

- Make sure you have all 4 pages (including this one), plus a periodic table.
- Make note of the point value of each question, and allocate your time accordingly.
- *Carefully* read each question before answering. Where appropriate, you must show your work to receive full credit.
- Include *units* and the proper *significant figures* in all numerical answers.
- With the exception of a non-programmable calculator, no aids or notes of any kind are permitted or required.

## Total Points: 32
## Total Time: 75 minutes

Potentially Helpful Information:

***Constants***

electron mass = $9.109 \times 10^{-31}$ kg

proton mass = $1.673 \times 10^{-27}$ kg

neutron mass = $1.675 \times 10^{-27}$ kg

1 u = $1.66054 \times 10^{-27}$ kg

h = $6.626 \times 10^{-34}$ Js

c = $2.998 \times 10^{8}$ m/s

$R_H = 2.178 \times 10^{-18}$ J

$a_0 = 5.29 \times 10^{-11}$ m

e = $1.602 \times 10^{-19}$ C

$N_A = 6.022 \times 10^{23}$ mol$^{-1}$

R = 8.3145 J/molK

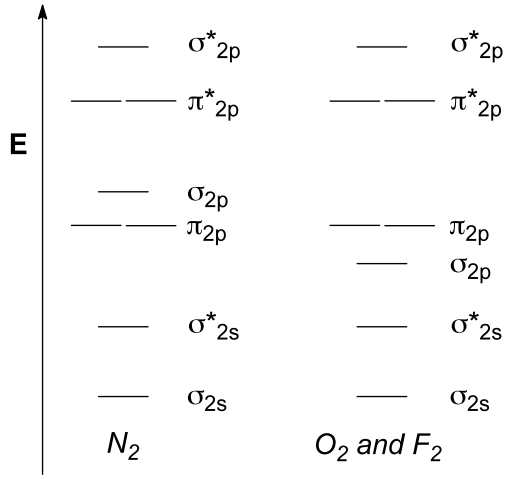
k = $1.381 \times 10^{-23}$ JK$^{-1}$

absolute zero = –273.15ºC

R = 0.082057 Latm/molK = 8.3145 J/molK

1 atm = 101.325 kPa = 760 torr

*Valence Molecular Orbital Diagrams*




***Equations***

$E = h\nu$ $\quad E = \frac{1}{2}mv^2$ $\quad E = mc^2$

$\lambda\nu = c$ $\quad \lambda = h/mv$ $\quad h\nu = h\nu_0 + KE$

$PV = nRT$ $\quad P = \frac{nRT}{V - nb} - a\frac{n^2}{V^2}$

$MM = \rho RT/P$ $\quad v_{rms} = \sqrt{\frac{3RT}{MM}}$ $\quad \frac{rate_A}{rate_B} = \sqrt{\frac{MM_B}{MM_A}}$

# CHEMISTRY 121 MIDTERM 3

Nov. 18, 2011

**(4) 1)** Briefly define **two** (not all four) of the following terms. Include an illustrative example.

**a)** effusion

**b)** paramagnetic

**c)** absolute zero

**d)** sigma bond

**(5) 2)** Circle the one best answer for the following questions.

**(i)** In honour of the best province in Canada, which diatomic molecule has a bond order of 1?

a) BC b) $[BC]^+$ c) $[BC]^-$ d) $[BC]^{2+}$

**(ii)** A 2.24 liter vessel of gas is at 0°C and 760 torr pressure. How many moles of the gas are present?

a) 0.100
b) 0.8206
c) 1.00
d) 10.0
e) 76.0

**(iii)** For which molecule does the central atom use $sp^2$ hybrid orbitals to form its bonds?

a) $NH_3$ b) $SO_2$ c) $BrF_3$ d) $CO_2$

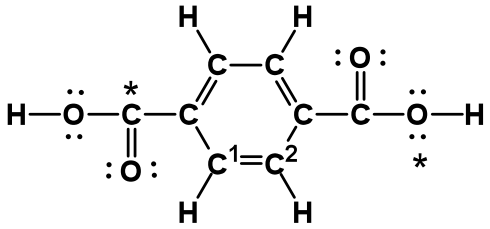
**(iv)** Which gas has the highest density?

a) $CH_4$ at 100ºC and 1.0 atm
b) $O_2$ at 100ºC and 1.0 atm
c) $CH_4$ at 0ºC and 1.0 atm
d) $O_2$ at 0ºC and 1.0 atm

**(v)** Rotation around a C=C (double bond) does not happen because:

a) a C=C $\pi$-bond is stronger than a C=C $\sigma$-bond.
b) a C=C double bond is stronger than a C-C single bond.
c) rotation about the C=C bond breaks both the $\sigma$ and $\pi$ bonds.
d) the C=C $\pi$ bond is due to overlap of orbitals perpendicular to the $\sigma$ bond axis.

**3)** The structure of terephthalic acid, a constituent of the plastic used to make pop bottles, is shown. Consider the six-membered carbon ring to lie in the xy plane.



**(1)** What is the expected hybridization of atomic orbitals at the C atom labeled with a ∗ symbol? _____

**(1)** What is the expected hybridization of atomic orbitals at the O atom labeled with a ∗ symbol? _____

**(1)** How many π bonds are in terephthalic acid? _____

**(2)** Which **two** specific orbitals overlap to form the σ bond(s) between the $C^1$ and H ? On $C^1$: _____ On H: _____

**(2)** Which **two** specific orbitals overlap to form the π bond(s) between the $C^1$ and $C^2$ ? On $C^1$: _____ On $C^2$: _____

**4)** Consider the following four molecular orbitals in the $N_2$ molecule, labeled **I** through **IV**. Answer the questions in the spaces provided.

**I** **II** **III** **IV**

**(1)** a) Which of these orbitals is the $\sigma^*_{2s}$ orbital? _____

**(1)** b) Which of these orbitals is **not** occupied by electrons? _____

**(1)** c) Which orbital is a π-antibonding molecular orbital? _____

**5)** Use the appropriate MO diagram to answer the following questions about the peroxide anion, $[O_2]^{2-}$. Show your work.

**(2)** a) What is the O-O bond order in the peroxide anion?

**(2)** b) Do you expect the peroxide anion to interact strongly with a magnetic field? Explain your reasoning.

**(2)** **c**) Explain whether the O-O bond in the superoxide anion, $[O_2]^-$, is expected to be longer or shorter than that in $[O_2]^{2-}$.

**6)** A 3.50 L balloon contains 9.93 g of a gas at 73.7 kPa and 36 ºC.

**(2)** a) Calculate the molar mass of the gas.

**(2)** b) What is the volume of the balloon if the temperature is lowered to 5ºC ? Assume a constant pressure.

**(3)** **7)** A balloon contains a mixture of 5.00 liters of $N_2$ and 5.00 liters of $O_2$. Gas escapes through a pinprick hole until half the $N_2$ remains in the balloon. What is the total volume of all gases remaining in the balloon?

**(1)** **Bonus**. What colour were the comment sheets on the recent teaching evaluations? _____