University of Waterloo

University of Waterloo
DEPARTMENT OF CHEMISTRY
CHEM 120 - Term Test #2
Wednesday, October 31, 2007

This is test version 007.
Fill in ovals 007 for the Card Number (or Test Master) on your computer answer card.

Name (Print clearly): _____
First name Surname

Student Number: _____ Signature: _____

Instructor (Section): C. Bissonnette (section 004)

Aids Allowed: Electronic Calculator

Time Allowed: 50 minutes

Instructions:

1. Print your name and other information in the top right corner on the front of the computer card.
2. Fill in your ID number, Section Number and your Card Number/Test Master in the designated fields.
3. **Use a pencil to fill in the ovals on the computer card.** Make sure any erasures are complete and clean. If you need a pencil, raise your hand and ask for one.
4. This test booklet has 12 questions and 7 pages (including this Cover Page and the Data Sheet). Check now to ensure that no pages are missing. **If pages are missing, raise your hand and ask for a new test booklet.**
5. There is only one correct answer for each question. **Circle A, B, C, D or E on this booklet**. When you have finished, **transfer your answers to the computer card** by filling in the appropriate oval (A,B,C,D or E) in the column for that question on the card.
6. Attempt all questions. No marks are deducted for wrong answers. Do all rough work on this test booklet. Scrap paper is not permitted.
7. At the end of the test, turn in this test booklet **.** the data sheet, and your computer card, and then leave immediately. **Do not put computer cards inside the test booklet!**

Note: The last page is a DATA SHEET. You may tear it off. Return it with your test booklet and computer card

1. Which of the following gases effuses three times as fast as HCl gas under the same conditions of temperature and pressure?

   A. He*

   B. BH_3

   C. SCl_2

   D. Ne

   E. S_2

2. Under what set of conditions are the deviations from ideal gas behaviour most evident?

   A. high temperature and low pressure

   B. low temperature and high pressure*

   C. high temperature and high pressure

   D. low temperature and low pressure

3. For which of the following processes is the constant pressure heat of reaction (Q_p) less than the constant volume heat of reaction (Q_v)?

   A. $2\ C(s) + O_2(g) \rightarrow 2\ CO(g)\ \ Q_p = Q_v + RT$

   B. $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)\ \ Q_p = Q_v + RT$

   C. $Mg(s) + 2\ HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)\ \ Q_p = Q_v + RT$

   D. $N_2(g) + 2\ H_2(g) \rightarrow N_2H_4(l)\ \ Q_p = Q_v - 3\ RT$ *

   E. $2\ LiOH(s) \rightarrow Li_2O(s) + H_2O(l)\ \ Q_p = Q_v$

4. A 0.91-g sample of sucrose, $C_{12}H_{22}O_{11}$ (molar mass, 342 g mol^{-1}), was placed in a bomb calorimeter with an excess amount of oxygen. The mixture was ignited and combustion to carbon dioxide and water was complete. The temperature rose by 3.50°C. If the heat capacity of the calorimeter was 4250 J $(^oC)^{-1}$, what is the constant volume heat of reaction? Choose the closest value.

   A. -14.9 kJ mol^{-1}

   B. -91 kJ mol^{-1}

   C. -5090 kJ mol^{-1}

   D. -5590 kJ mol^{-1}*

   E. $-14\,900$ kJ mol^{-1}

5. Consider the following thermochemical equations.

$$SO_2(g) + \tfrac{1}{2}\,O_2(g) \rightarrow SO_3(g), \qquad \Delta H^o = -98.9 \text{ kJ (per mol } SO_2)$$

$$3\,SO_2(g) \rightarrow S(s) + 2\,SO_3(g), \qquad \Delta H^o = +99.0 \text{ kJ (per mol S)}$$

   What is the standard enthalpy of formation of $SO_2(g)$?

   A. 98.9 kJ mol^{-1}

   B. 66.0 kJ mol^{-1}

   C. -33.0 kJ mol^{-1}

   D. -197.9 kJ mol^{-1}

   E. -296.8 kJ mol^{-1}*

6. What is the internal energy change, ΔU, for a gas that absorbs 452 J of heat and expands from 25.0 L to 55.0 L against a constant external pressure of 99.6 kPa?

A. −2536 J*

B. −2988 J

C. +452 J

D. +2988 J

E. +3440 J

7. What is the enthalpy change for the reaction below, per mole of C_8H_8? Choose the closest value. (Standard enthalpies of formation are given in the table.)

$$C_8H_8(l) + 10\ O_2(g) \rightarrow 8\ CO_2(g) + 4\ H_2O(l)$$

Substance	ΔH_f^o (in kJ mol^{-1})
$C_8H_8(l)$	−103.8
$CO_2(g)$	−393.5
$H_2O(l)$	−285.9

A. −575.5 kJ

B. −4188 kJ*

C. −4395 kJ

D. −756.2 kJ

E. cannot be determined because ΔH_f^o for $O_2(g)$ is not given

8. Which one of the following statements is **true**?

   A. It is impossible to make simultaneous measurements of both the position and the momentum of an electron. (F)

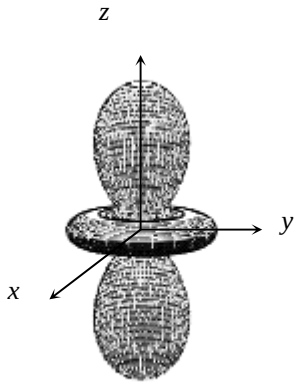
   B. The de Broglie wavelength of an electron increases as the speed of the electron increases. (F)

   C. Each line in the line spectrum of the H atom corresponds to the energy of a specific electron orbital. (F)

   D. For the hydrogen atom, the energy of the 2*s* orbital is lower than that of a 2*p* orbital. (F)

   E. None of the statements above are true. (T)*

9. The 90% probability contour for an orbital is shown below. Which orbital could it be?



   A. $2p_z$

   B. $3p_z$

   C. $3d_{x^2-y^2}$

   D. $3d_{z^2}$ *

   E. $3d_{xy}$

10. Orbitals with $l = 4$ are called *g* orbitals. What is the minimum value of the magnetic quantum number, m_l, for an electron in a *g* orbital?

   A. 0

   B. 1

   C. 3

   D. −½

   E. −4*

11. The electron in a hydrogen atom undergoes a transition from a 2*p* orbital to the 6*s* orbital when the atom absorbs a single photon. What is the wavelength of the absorbed photon? ($1\ \text{nm} = 1\times10^{-9}\ \text{m}$)

    A. 410 nm*

    B. 365 nm

    C. 328 nm

    D. 285 nm

    E. 273 nm

12. How many radial nodes and nodal planes are there for a hydrogen-like $4d_{xy}$ orbital?

    A. There are four radial nodes and zero nodal planes.

    B. There are three radial nodes and two nodal planes.

    C. There are two radial nodes and two nodal planes.

    D. There is one radial node and two nodal planes. *

    E. There is one radial node and three nodal planes.

DETACH THIS DATA SHEET FOR EASY REFERENCE

1 **1A**																	**18** **8A**
1 **H** 1.008	**2** **2A**											**13** **3A**	**14** **4A**	**15** **5A**	**16** **6A**	**17** **7A**	2 **He** 4.003
3 **Li** 6.941	4 **Be** 9.012											5 **B** 10.81	6 **C** 12.01	7 **N** 14.01	8 **O** 16.00	9 **F** 19.00	10 **Ne** 20.18
11 **Na** 22.99	12 **Mg** 24.31	**3** **3B**	**4** **4B**	**5** **5B**	**6** **6B**	**7** **7B**	**8** **←**	**9** **8B**	**10** **→**	**11** **1B**	**12** **2B**	13 **Al** 26.98	14 **Si** 28.09	15 **P** 30.97	16 **S** 32.07	17 **Cl** 35.45	18 **Ar** 39.95
19 **K** 39.10	20 **Ca** 40.08	21 **Sc** 44.96	22 **Ti** 47.88	23 **V** 50.94	24 **Cr** 52.00	25 **Mn** 54.94	26 **Fe** 55.85	27 **Co** 58.93	28 **Ni** 58.69	29 **Cu** 63.55	30 **Zn** 65.38	31 **Ga** 69.72	32 **Ge** 72.59	33 **As** 74.92	34 **Se** 78.96	35 **Br** 79.90	36 **Kr** 83.80
37 **Rb** 85.47	38 **Sr** 87.62	39 **Y** 88.91	40 **Zr** 91.22	41 **Nb** 92.91	42 **Mo** 95.94	43 **Tc** (98)	44 **Ru** 101.1	45 **Rh** 102.9	46 **Pd** 106.4	47 **Ag** 107.9	48 **Cd** 112.4	49 **In** 114.8	50 **Sn** 118.7	51 **Sb** 121.8	52 **Te** 127.6	53 **I** 126.9	54 **Xe** 131.3
55 **Cs** 132.9	56 **Ba** 137.3	(57-71) **La-Lu**	72 **Hf** 178.5	73 **Ta** 180.9	74 **W** 183.9	75 **Re** 186.2	76 **Os** 190.2	77 **Ir** 192.2	78 **Pt** 195.1	79 **Au** 197.0	80 **Hg** 200.6	81 **Tl** 204.4	82 **Pb** 207.2	83 **Bi** 209.0	84 **Po** (209)	85 **At** (210)	86 **Rn** (222)
87 **Fr** (223)	88 **Ra** 226	(89-103) **Ac-Lr**	104 **Rf**	105 **Db**	106 **Sg**	107 **Bh**	108 **Hs**	109 **Mt**	110 **Uun**	111 **Uuu**	112 **Uub**	113 **Uut**					

Constants:

$N_A = 6.022\times10^{23}$ mol^{-1} $R_H = 2.179\times10^{-18}$ J (Rydberg constant)

R = 0.082058 atm L K^{-1} mol^{-1} $c = 2.998\times10^{8}$ m s^{-1} $e = 1.602\times10^{-19}$ C

= 8.3145 kPa L K^{-1} mol^{-1} $h = 6.626\times10^{-34}$ J s $\pi = 3.141592654$

= 8.3145 J K^{-1} mol^{-1} $m_e = 9.109\times10^{-31}$ kg

Conversion factors:

1 atm = 101.325 kPa 1 kPa L = 1 J = 1 Pa m^3 1 cal = 4.184 J 1 nm = 10^{-9} m

1 atm = 760 torr 1 atm L = 101.325 J 1 m^3 = 1000 L 1 pm = 10^{-12} m

1 atm = 760 mmHg $0^oC = 273.15$ K 1 amu = 1.6605×10^{-27} kg

Key Equations:

$PV = nRT$ $(P + an^2/V^2)(V - nb) = nRT$ $w = -P_{ext}\,\Delta V$ $q = C\,\Delta T$ $\Delta U = q + w$

$H = U + PV$ $\Delta H = \Delta U + \Delta n\,RT$ $c = \lambda\nu$ $\lambda = h/p$ $p = mv$

$\Delta x\,\Delta p \geq h/(4\pi)$ $E = h\nu$ $E_n = -R_H/n^2$ $\mu = \delta r$ B.O. $= \frac{1}{2}(n_b - n_a)$

$(rate)_2/(rate)_1 = \sqrt{M_1/M_2}$ $KE = \frac{1}{2}mv^2$