THE COLLEGE OF THE BAHAMAS
SCHOOL OF NATURAL SCIENCES AND ENVIRONMENTAL STUDIES

DEPARTMENT OF CHEMISTRY
FINAL EXAMINATION SEMESTER 042004

CHEMISTRY 135 : COLLEGE CHEMISTRY 1

STUDENT NAME: .....

STUDENT NUMBER: .....

COURSE SECTION: .....

TIME: 3 HOURS

The following information may be required.

- Gas constant, R = 8.31 J $mol^{-1} K^{-1}$ = 0.0821 dm^3 atm $mol^{-1} K^{-1}$
- 1 atm = 760 mmHg = 101 325 Pa
- Molar volume of any gas at s.t.p. is 22.4 $dm^3 mol^{-1}$
- Avogadro's number is 6.022×10^{23}.
- Periodic tables are provided.

Section I: Multiple Choice Questions

Five possible answers are given to each question in this section. Choose the one you consider to be correct. Each question in this section is worth one mark, for a total of 28 marks.

1) A real gas most closely approaches the behaviour of an ideal gas at

   A 0.50 atm and 500 K
   B 1 atm and 273 K
   C 1 atm and 298 K
   D 15 atm and 500 K
   E 15 atm and 200 K

2) At standard temperature and pressure, 7 g O_2 will occupy

   A 497.1 dm^3
   B 248.6 dm^3
   C 32.4 dm^3
   D 9.82 dm^3
   E 4.91 dm^3

3) What volume of 0.25 M Na_2SO_4 contains the same number of moles as 100 cm^3 of 0.75 M Na_2SO_4?

   A 4 cm^3
   B 33 cm^3
   C 300 cm^3
   D 400 cm^3
   E 250 cm^3

4) A 3 dm^3 solution of concentration 2.0 M NaCl is diluted to a volume of 5.0 dm^3. The final concentration of NaCl is

   A 1.6 M
   B 1.2 M
   C 0.8 M
   D 3.3 M
   E 1.5 M

5) Which statement is *false*?

   A In general, atomic radii increase from right to left across a period.
   B In general, atomic radii increase from top to bottom down a group.
   C Hydrogen possesses the smallest atomic radius.
   D Across a period, the outer electrons are attracted more strongly and pulled towards the nucleus.
   E Effective nuclear charge has no effect on atomic radius.

6) A mixture of CO(g) and CO_2(g) contains 5 mol of CO(g) for every 3 mol of CO_2(g). The partial pressure of CO_2(g) is

A three fifths the total pressure
B one third the total pressure
C five eighths the total pressure
D three eighths the total pressure
E impossible to determine

7) At what temperature will 0.100 mol of CO_2 occupy 3.00 dm^3 at 1.31 atm?

A 499 K
B 479 K
C 459 K
D 394 K
E 365 K

8) Which occurrence would make the actual amount of product obtained in a chemical reaction less than the theoretical amount?

A side reactions.
B the reaction did not go to completion.
C product was lost during the separation and purification process.
D impurities were present in more than one of the reactants.
E any of these will make the actual yield less than the theoretical yield.

9) Which ion is *not* isoelectronic with the argon atom?

A Na^+
B Cl^-
C Ca^{2+}
D K^+
E Sc^{3+}

10) Which of the following is non-polar, but contains polar bonds?

A HCl
B H_2O
C NH_3
D CO
E CCl_4

11) The total number of valence electrons in the phosphonium ion, PH_4^+, is

A 8
B 9
C 10
D 12
E 18

12) Ammonia, NH_3 and boron trifluoride, BF_3 react spontaneously to form the complex $F_3B - NH_3$. The bond between the boron and nitrogen atom of this complex is best described as

A a hydrogen bond
B an ionic bond
C a coordinate covalent bond
D a covalent bond
E a dipole dipole interaction

13) Electronegativity *increases* in the following order

A Cl, S, P, Si
B I, Br, Se, As
C C, N, O, F
D Cl, Br, I, At
E F, S, As, Sn

14) For which of the following substances does $\Delta_f H° = 0$?

A I_2(g)
B Cl(g)
C H(g)
D NO(g)
E He(g)

15) 50 g of an ionic compound XY_2 (RFM=1000) were dissolved in water and made up to 1 dm^3. What is the concentration of the solution with respect to Y^+ ions?

A 0.05 M
B 0.10 M
C 0.15 M
D 0.20 M
E 0.40 M

16) Using the given standard enthalpies of formation,

$\Delta_f H(H_2O, l) = -285.8\,kJ\,mol^{-1}$,
$\Delta_f H(HCl, g) = -92.3\,kJ\,mol^{-1}$

the enthalpy change for the reaction,
$2\,Cl_2(g) + 2\,H_2O(l) \longrightarrow 4\,HCl(g) + O_2(g)$
in $kJ\,mol^{-1}$ is

A 193.5
B −83.4
C −940.0
D 202.4
E 479.3

17) What intermolecular forces are possible between molecules of HF?

A London forces and dipole-dipole interactions
B dipole-dipole interactions and hydrogen bonding
C London forces, dipole-dipole interactions, and hydrogen bonding
D London forces only
E Hydrogen bonding only

18) 2 mol of benzoic acid, C_6H_5COOH, contains

A 2 mol of oxygen atoms
B 6 mol of hydrogen atoms
C 10 mol of hydrogen atoms
D 12 mol of carbon atoms
E 14 mol of carbon atoms

19) For the following elements, the correct order of *increasing* first ionization energy is

A Be > Li > F > Na
B Li > Be > F > Na
C Na > Be > Li > F
D F > Be > Li > Na
E Na > Li > Be > F

20) How many cm^3 of a 0.610 M NaOH solution are needed to completely neutralize 20.0 cm^3 of 0.245 M H_2SO_4? From the equation,

$n H_2SO_4(aq) : n NaOH(aq)$
1 : 2

A 16.1
B 19.3
C 22.1
D 18.5
E 20.5

21) A colorless solution gives a white precipitate when treated with either sodium hydroxide or ammonia solution. In both cases the precipitate redissolves in excess. The original solution contained

A zinc ions
B ammonium ions
C copper(II) ions
D iron(II) ions
E sodium ions

22) What is the volume SO_2 formed at s.t.p. when 0.5 mol of carbon disulphide, CS_2 is burned in excess oxygen? The equation for the reaction is
$CS_2(g) + 3\,O_2(g) \longrightarrow CO_2(g) + 2\,SO_2(g)$

A 1 dm^3
B 5.6 dm^3
C 11.2 dm^3
D 22.4 dm^3
E impossible to determine

QUESTIONS 23-25 concern the following: Elements may be classified as

A noble gases
B s-block
C p-block
D d-block
E f-block

Select from A to E, the classification of

23) the element with the electronic configuration $(^{18}Ar)\,3d^5 4s^1$

24) the element whose anion has the electronic configuration $1s^2 2s^2 2p^6 3s^2 3p^6$

25) the element with the electronic configuration $(^{36}Kr)\,5s^2$

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26) Which equation represents the standard enthalpy of formation of water, $\Delta_f H°(H_2O, l)$?

A $2\,H(g) + O(g) \longrightarrow H_2O(l)$
B $2\,H_2(g) + O_2(g) \longrightarrow 2\,H_2O(l)$
C $H_2(l) + \frac{1}{2}\,O_2(l) \longrightarrow H_2O(l)$
D $H_2(g) + \frac{1}{2}\,O_2(g) \longrightarrow H_2O(l)$
E $4\,H(g) + 2\,O(g) \longrightarrow 2\,H_2O(l)$

27) Which of the quantum state designations, is a forbidden state for an electron in an atom?

I $n = 3$ $l = 2$ $m_l = -2$
II $n = 3$ $l = 1$ $m_l = 0$
III $n = 3$ $l = 0$ $m_l = -1$
IV $n = 3$ $l = 2$ $m_l = 0$
V $n = 3$ $l = 2$ $m_l = -2$

A I
B II
C III
D IV
E V

28) A 0.20 mol sample of a hydrocarbon, C_xH_y yields, after complete combustion with excess O_2, 0.8 mol of CO_2 and 1.0 mol of H_2O. The equation for the reaction is

$$C_xH_y + \left(x + \frac{y}{4}\right) O_2 \longrightarrow x\,CO_2 + \frac{y}{2}\,H_2O$$

The molecular formula of C_xH_y is

A C_4H_{10}
B C_4H_8
C C_4H_5
D C_8H_{16}
E C_8H_{10}

Section II: Structured Questions

Answer each of the following questions in the spaces provided on the question paper. Clear and concise expression is an essential part of a good answer. This section is worth a total of 62 marks.

1) The commonly used pain reliever, aspirin, has the molecular formula, $C_9H_8O_4$.

a) i) What is the molar mass of aspirin? (1 mark)

ii) What is the percentage by mass of hydrogen in aspirin? (2 marks)

iii) How many molecules of aspirin are in a sample of mass 0.875 g? (3 marks)

iv) How many carbon atoms are in a sample of aspirin of mass 0.875 g? (2 marks)

b) Aspirin,$C_9H_8O_4$, burns in oxygen gas, to gaseous CO_2 and liquid H_2O. How many moles of H_2O will be formed when a mixture containing 3.90 g of aspirin and 3.90 g of oxygen is ignited? The equation for the combustion is (4 marks)

$$C_9H_8O_4(s) + 9\,O_2(g) \longrightarrow 9\,CO_2(g) + 4\,H_2O(l)$$

2) The standard enthalpy of combustion of ethane gas, C_2H_6 to produce carbon dioxide gas and liquid water is $-1559\,\text{kJ mol}^{-1}$. The equation for the reaction is

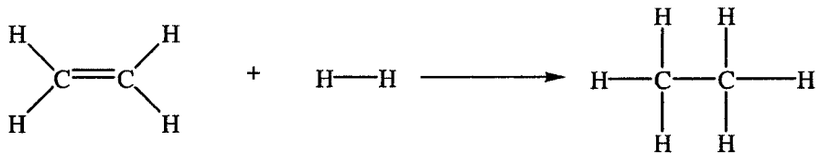
$$C_2H_6(g) + \frac{7}{2}O_2(g) \longrightarrow 2\,CO_2(g) + 3\,H_2O(l)$$

Given $\Delta_f H(CO_2, g) = -393.5\,\text{kJ mol}^{-1}$ and $\Delta_f H(H_2O, l) = -285.8\,\text{kJ mol}^{-1}$

a) Calculate $\Delta_f H°(C_2H_6, g)$ (4 marks)

b) Given that the standard enthalpy of combustion of ethane gas is $-1559\,\text{kJ mol}^{-1}$, calculate the volume of ethane (in dm^3), measured at stp, that must be burned to supply enough energy to raise the temperature of 50 kg of water at 10 °C to steam at 90 °C? The specific heat capacity of water is $4.18\,\text{J g}^{-1}\,\text{K}^{-1}$.
(4 marks)

c) Use the average bond energies below to estimate a value for the standard enthalpy change , $\Delta H°$, for the reaction. (4 marks)



Bond	Bond energies/kJ mol^{-1},
C – C	348
C = C	615
H – H	436
C – H	413

3) a) Draw the Lewis structures and use VSEPR theory predict the shapes of: (8 marks)

Compound	Lewis structure	Shape
ICl^-		
XeO_3		
BrNO		
Cl_2SO (S is the central atom)		

b) CF_4 and PF_3 have approximately the same molar mass and they both have 42 electrons. The melting and boiling points of these two compounds are

Compound	melting point / °C	boiling point / °C
CF_4	−184	−128
PF_3	−151.5	−101.5

Explain why CF_4 has a *lower* melting point and boiling point than PF_3. (3 marks)

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4) a) A certain volume of an unknown gas, X, weighs 8.25 g under certain conditions of temperature and pressure. The same volume of nitrogen gas under the same conditions weighs 2.00 g.

i) Calculate the relative molecular mass of gas X. (3 marks)

ii) If the gas in part a) is found on analysis to consist of 30.7% chlorine and 69.3% bromine find its molecular formula. (3 marks)

b) A flask of unknown volume was filled with nitrogen gas to a pressure of 3.6 atm. This flask was then attached to an evacuated flask with a known volume of 4.9 dm^3, and the nitrogen was allowed to expand into the flask. The final pressure of the nitrogen (in both flasks) was 2.5 atm. Determine the volume of the first flask? (3 marks)

c) A sample of gas, G, takes 1.85 times longer than nitrogen gas to effuse through a tiny hole in a gas cylinder. What is the RMM of gas G? (3 marks)

5) a) In the ground state of $_{37}$Rb the full ground- state electron configuration is $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6 5s^1$:

i) How many electrons have $l = 0$ as one of their quantum numbers? (2 marks)

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ii) How many electrons have $m = -1$ as one of their quantum numbers? (2 marks)

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iii) How many degenerate atomic orbitals are there in $_{37}$Rb that can be designated 4p? (2 marks)

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iv) What is the maximum number of electrons that can be accommodated in all orbitals with principal quantum number $n = 4$? (2 marks)

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b) Write the full ground-state electronic configurations (ie: see configuration for $_{37}$Rb) for each of the following atom/ion: (2 marks)

$_{23}$V: ..... $_{24}Cr^{3+}$: .....

c) Which of the following three ions has the smallest ionic radius? Explain your reasoning. (3 marks)

Sc^{3+} Cl^- Ca^{2+}

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d) Draw orbital diagrams for the ground state electron configurations of $_{33}$As and $_{34}$Se. For example, the orbital diagram of nickel, Ni in the same period would be (2 marks)

(^{18}Ar) $\underline{\uparrow\downarrow}$ (4s) | $\underline{\uparrow\downarrow}$ $\underline{\uparrow\downarrow}$ $\underline{\uparrow\downarrow}$ (3d) $\underline{\uparrow}$ $\underline{\uparrow}$

$_{33}$As: .....

$_{34}$Se: .....