THE COLLEGE OF THE BAHAMAS

EXAMINATION

SEMESTER 01-2006

FACULTY OF PURE AND APPLIED SCIENCES
SCHOOL OF SCIENCES AND TECHNOLOGY

X NASSAU
FREEPORT
EXUMA
ELEUTHERA

DATE AND TIME OF EXAMINATION: Thursday, April 20, 2006 at 9 am
DURATION: 2 ½ HOURS

COURSE NUMBER: CHEM 135

COURSE TITLE: COLLEGE CHEMISTRY I

STUDENT NAME:

STUDENT NUMBER:

LECTURER'S NAME

INSTRUCTIONS TO CANDIDATES: This paper has 12 pages and 46 questions. Please follow instructions given.

The following information may be useful:

1 atm = 101 000 Pa = 760 torr

The molar volume of any gas at s.t.p. is 22.4 $L.mol^{-1}$

$R = 8.31\ J.mol^{-1}.K^{-1} = 0.0821\ L.atm.mol^{-1}.K^{-1} = 62.4\ L.torr.mol^{-1}.K^{-1}$.

Avogadro's number = 6.02×10^{23}

PERIODIC TABLE OF THE ELEMENTS

showing atomic numbers and relative atomic masses

I	II											III	IV	V	VI	VII	VIII
1																	2
H																	He
1.0																	4.0
3	4											5	6	7	8	9	10
Li	Be											B	C	N	O	F	Ne
6.9	9.0											10.8	12.0	14.0	16.0	19.0	20.2
11	12											13	14	15	16	17	18
Na	Mg											Al	Si	P	S	Cl	Ar
23.0	24.3											27.0	28.1	31.0	32.1	35.5	39.9
19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
39.1	40.1	45.0	47.9	50.9	52.0	54.9	55.8	58.9	58.7	63.5	65.4	69.7	72.6	74.9	79.0	79.9	83.8
37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
85.5	87.6	88.9	91.2	92.9	95.9	98.9	101.1	102.9	106.4	107.9	112.4	114.8	118.7	121.8	127.6	126.9	131.3
55	56	57	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
132.9	137.3	138.9	178.5	180.9	183.85	186.2	190.2	192.2	195.1	197.0	200.6	204.4	207.2	209.0			
87	88	89															
Fr	Ra	Ac															

	58	59	60	61	62	63	64	65	66	67	68	69	70	71
	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
	90	91	92	93	94	95	06	97	98	99	100	101	102	103
	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

SECTION I: Multiple Choice Questions

Select the SINGLE best alternative in each of the following cases and mark the appropriate letter on the separate answer sheet by shading with a soft pencil. Answer ALL questions in this section.

Questions 1 - 5 refer to the ground state electronic configurations of five elements A to E. Each configuration may be used once, more than once, or not at all.

A $\quad 1s^2 2s^2 2p^6 3s^2 3p^2$
B $\quad 1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$
C $\quad 1s^2 2s^2 2p^6 3s^2 3p^6 3d^1 4s^2$
D $\quad 1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^4$
E $\quad 1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6$

Select from A to E the element which:

1) is a noble gas.
2) is a transition metal.
3) forms an ion of charge +2.
4) forms an ion of charge -2.
5) forms a chloride of formula XCl_4

Questions 6 - 10 refer to the five graphs labelled A, B, C, D, E in the diagram below.
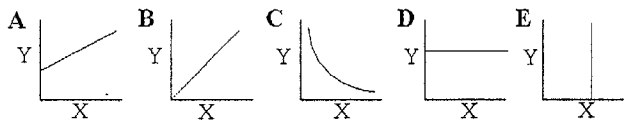
For each graph, a quantity Y is plotted against a quantity X for a *fixed mass of an ideal gas*. Select from A to E the graph which best represents the relationship between the quantities Y and X, under the stated conditions. Each graph may be used once, more than once, or not at all.

QUANTITY Y	QUANTITY X	CONDITIONS
6) density	RMM	constant T & P
7) (rate of effusion)^2	density	constant T & P
8) kinetic energy of molecules	pressure	constant temperature
9) pressure	temperature in °C	constant volume
10) volume	temperature in K	constant pressure

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Questions 11 - 13 refer to two flasks of volume 1 L containing 32 g each of oxygen and sulfur dioxide respectively, at the same temperature. (O = 16, S = 32)

11) The ratio

number of molecules of oxygen	:	number of molecules of sulfur dioxide

is:
A 1:1
B 1:2
C 1:4
D 2:1
E 4:1

12) The ratio

density of oxygen	:	density of sulfur dioxide

is:
A 1:1
B 1:2
C 1:4
D 2:1
E 4:1

13) The ratio

average kinetic energy per oxygen molecule	:	average kinetic energy per sulfur dioxide molecule

is:
A 1:1
B 1:2
C 1:4
D 2:1
E 4:1

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14) According to the kinetic theory of gases, the molecules of an ideal gas
A all have the same velocity.
B are tiny charged particles.
C do not attract each other.
D are of appreciable volume.
E sometimes stick together when they collide.

15) 10 cm^3 of a hydrocarbon react with excess oxygen to produce 10 cm^3 of carbon dioxide. Which of the following is the most likely formula of the hydrocarbon?

A CH_4
B C_2H_6
C C_3H_4
D C_4H_{10}
E C_5H_{12}

16) Which one of the following particles is expected to be the smallest?

A Na^+
B Mg^{2+}
C Al^{3+}
D S^{2-}
E Cl^-

17) A molecule of the compound XCl_3 has zero dipole moment. What is its shape?

A linear
B trigonal planar
C tetrahedral
D triangular pyramidal
E square planar

18) Which one of the following molecules is expected to have the highest dipole moment?

A F
B IBr
C BrCl
D IF
E BrCl

19) Which one of the following molecules is electron deficient?

A H_2O
B SiF_4
C BF_3
D HF
E H_2S

20) In any one group of the periodic table, the atomic radius increases with increasing atomic number. Which *one* of the following factors is most responsible for this?

A The increasing number of electron shells.
B The increasing number of neutrons in the nucleus.
C The decreasing ionization energy.
D The increasing nuclear charge.
E The increasing atomic mass.

21) The diagram below shows the logarithm of the first seven ionization energies of the element Q.
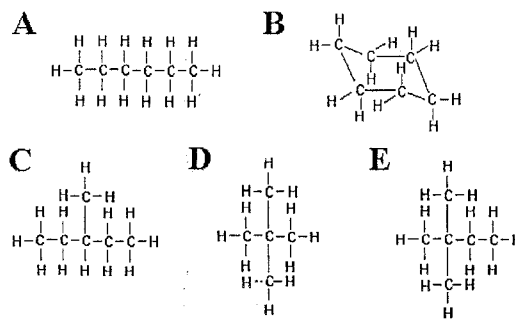

Electron removed
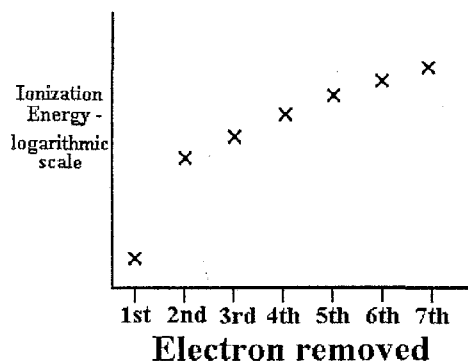
Element Q is most likely to be:
A fluorine
B lithium
C aluminium
D chlorine
E sodium

22) Which one of the following does not have the same electronic structure as the argon atom?

A Ca^{2+}
B Cl^-
C Al^{3+}
D S^{2-}
E K^+

23) Which one of the following alkanes is expected to have the highest boiling point?

24) Which one of the following statements about electron affinities is correct?

A They are always negative.
B They are always positive.
C Electron affinity increases down any group.
D Electron affinity decreases across any period.
E Electron affinity represents the energy change when an extra electron is added to an atom.

25) Which one of the following rules best explains why calcium has two electrons in its *4s* orbital, but none in its *3d* orbitals?

A All orbitals with a given value of *n* have the same energy.

B   Electrons may only occupy the same orbital if their spins are paired.

C   Orbitals with the same energy are described as degenerate orbitals.

D   A set of orbitals of equal energy will each be occupied by one electron before any pairing occurs.

E   In many-electron atoms $3d$ orbitals are of higher energy than $4s$ orbitals.

26) Which sentence best relates to molecular substances?

A   A metal atom donates an electron to fill the octet of a non-metal atom.

B   Ions of opposite charge are attracted to one another.

C   Cations are present in a sea of mobile valence electrons.

D   A non-metal atom donates a pair of electrons to an empty outer shell of a metal ion.

E   Atoms form small groups in which the atoms are strongly bonded together, but with only weak forces holding one group to the next.

27) The average bond energy for Cl_2 is 245 kJ.mol^{-1}. The energy required to break one bond between a pair of individual chlorine atoms is therefore:

A   245 kJ

B $\dfrac{6.02 \times 10^{23}}{245}$ kJ

C $\dfrac{245}{6.0 \times 10^{23}}$ kJ

D $(245 \times 6.02 \times 10^{23})$ kJ

E   None of the above

28) Which of the following sets of elements has atomic radii which change only slightly with increasing atomic number?

A   the noble gases
B   the halogens
C   the transition elements
D   the alkali metals
E   the alkaline earth metals

29) How many moles of nitrate ions are there in 200 cm^3 of 1.5 M iron(II) nitrate?

A $0.200 \times 1.5 \times 6.02 \times 10^{23}$ mol
B $0.200 \times 1.5 \times 2$ mol

C $0.200 \times 1.5 \times 3$ mol
D $200 \times 1.5 \times 2$ mol
E $\dfrac{200 \times 2}{1.5}$ mol

30) When 0.01 mol of HCl solution is mixed with 0.01 mol of NaOH solution in a container to make 200 cm^3 of mixture, the temperature of the mixture rises from 24.50°C to 31.00°C. If the container has negligible heat capacity, and the specific heat capacity of the mixture is 4.2 J.K^{-1}.cm^{-3}, what is the molar enthalpy change for the reaction

$HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l)$?

A $\dfrac{6.5 \times 4.2 \times 200 \times 10^{-3}}{0.0100}$ kJ.mol^{-1}

B $\dfrac{6.5 \times 200 \times 10^{-3}}{4.2 \times 0.0100}$ kJ.mol^{-1}

C $\dfrac{4.2 \times 200 \times 10^{-3}}{0.0100}$ kJ.mol^{-1}

D $\dfrac{6.5 \times 4.2 \times 200 \times 10^3}{0.0100}$ kJ.mol^{-1}

E $\dfrac{6.5 \times 4.2 \times 1}{200 \times 10^{-3} \times 0.0100}$ kJ.mol^{-1}

31) A balloon filled with air deflates in 56 hours as air escapes by effusion. How long (to 2 sig. figs.) does it take for a similar balloon filled with helium to deflate? (RMM of air = 28 and of helium = 4.0, temperature and pressure are constant.)

A   1.1 hours
B   8.0 hours
C   21 hours
D   39 hours
E   150 hours

32) Ammonia burns in oxygen in the presence of a catalyst according to the equation

$4NH_3(g) + 5O_2(g) \rightarrow 4NO(g) + 6H_2O(l)$

If 60 cm^3 of ammonia is burned completely in oxygen (all volumes being measured at the same temperature and pressure) then the volume of oxygen consumed is

A   4 cm^3
B   5 cm^3
C   48 cm^3
D   60 cm^3
E   75 cm^3

33) What volume of water must be added to 500 cm^3 of a 0.12 M solution of sodium carbonate to give a 0.040 M solution?
A   20 cm^3
B   200 cm^3
C   1000 cm^3
D   1500 cm^3
E   12 500 cm^3

34) 300 cm^3 of a 2.00 M solution of KNO_3 is mixed with 200 cm^3 of a 3.00 M solution of KNO_3. The concentration of the resulting solution is

A   2.00M
B   2.40M
C   2.50M
D   3.00M
E   5.00M

35) Which one of the following processes is exothermic?
A $Al(g) \rightarrow Al^{3+}(g) + 3e^-$
B $O(g) + e^- \rightarrow O^-(g)$
C $O^-(g) + e^- \rightarrow O^{2-}(g)$
D $Al(s) \rightarrow Al(g)$
E $O_2(g) \rightarrow 2O(g)$

36) A colourless solution gives a dense white precipitate when a little silver nitrate solution is added. The precipitate does not dissolve on the addition of dilute nitric acid. Which one of the following ions must be present?
A   sodium
B   calcium
C   carbonate
D   sulfite
E   chloride

37) A colourless solution gives a brown precipitate when treated with sodium hydroxide solution. The precipitate is insoluble in excess. Which one of the following ions is most likely to be present?
A   silver
B   iron(II)
C   dichromate
D   copper(II)
E   sulfite

38) Half the distance between neighbouring atoms in solid neon is known as the
A   bonding radius of a neon atom.
B   non-bonding radius of a neon atom.
C   metallic radius of a neon atom.
D   ionic radius of a neon atom.
E   bond length of a neon molecule.

39) A full d-subshell can hold a maximum of
A   1 electron
B   2 electrons
C   5 electrons
D   6 electrons
E   10 electrons

40) In which of the following substances would you LEAST expect hydrogen bonding to be present when the substance is liquid?
A NH_3
B H_2O
C   HF
D CH_4
E CH_3CH_2OH

SECTION II: Structured Questions

Answer ALL of the following questions in the spaces provided on the question paper.
NB: marks will only be awarded to answers supported by logical argument, mentioning principles and laws wherever used. Numerical answers must carry units where appropriate, and must be expressed to the correct number of significant figures.

1) Draw Lewis structures for each of the following molecules. Indicate the shape of each molecule in words AND with a stereochemical diagram, according to VSEPR theory. Show ALL valence electrons for the central atom in your Lewis structures. (9)

	MOLECULE	LEWIS STRUCTURE	SHAPE
a)	SiF_4		
b)	BrF_5		
c)	H_2O		

2) a) Dalton's law of Partial Pressures states that the total pressure exerted by a mixture of gases is equal to the sum of the partial pressures of the constituent gases.

   i) Explain what is meant by the *partial pressure* of a gas. (2)

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ii) A flask of volume 400 cm^3 contains a gas X at a pressure of 120 torr. Another flask, of volume 200 cm^3 contains gas Y at 300 torr. The two flasks are connected. Find the total pressure in the system when it has reached a steady state. All pressures are measured at the same temperature. (3)

b) 2.12 L of a gas is collected at 25°C and a pressure of 734.5 torr.
   i) Find the number of moles of the gas. (5)

ii) If the mass of the gas is 4.04 g, find the molar mass of the gas. (2)

3) Give explanations for ANY THREE of the following observations in terms of intermolecular forces, including diagrams if you wish.

a) H_2O has a higher boiling point than H_2S, even though the RMM of H_2S is larger. (4)

b) Pentane has a higher boiling point than neopentane (2,2-dimethylpropane) even though they have the same RMM. (4)

H H H H H
| | | | |
H-C-C-C-C-C-H
| | | | |
H H H H H
Pentane

H
|
H-C-H
H | H
| | |
H-C-C-C-H
| | |
H | H
H-C-H
|
H
Neopentane
(2,2-dimethylpropane)

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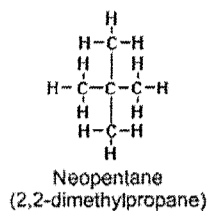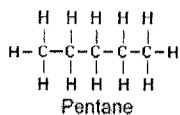
c) Ethanol is soluble in water, whereas propane is not. (4)

H H H
| | |
H-C-C-C-H
| | |
H H H
Propane

H H
| |
H-C-C-O-H
| |
H H
CH_3CH_2OH
Ethanol

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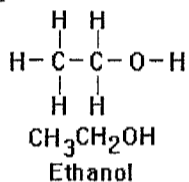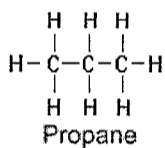
d) Water expands on freezing. (4)

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e) NaCl is soluble in water but not in hexane. (4)

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4) a) Some average bond energies at 298K are:

$C{\equiv}C$ 835 kJ mol^{-1}
C-C   346 kJ mol^{-1}
C-H   413 kJ mol^{-1}
H-H   436 kJ mol^{-1}
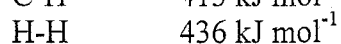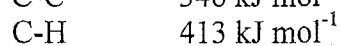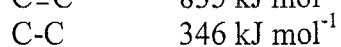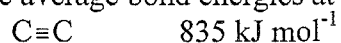
Calculate the enthalpy change (ΔH) for the reaction

$2H_2(g) + HC{\equiv}CH(g) \rightarrow CH_3CH_3(g)$ (3)
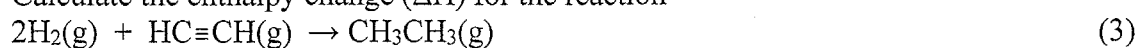
b) i) Write a balanced equation for the combustion of propane, C_3H_8. (2)

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    ii)   Given that the standard enthalpies of formation of propane (C_3H_8), carbon dioxide (CO_2) and water (H_2O) are $-104\triangle kJ\triangle mol^{-1}$, $-393\triangle kJ\triangle mol^{-1}$, and $-286\triangle kJ\triangle mol^{-1}$ respectively, calculate the standard enthalpy of combustion of propane.   (3)

5)   Explain each of the following statements about the periodic table by reference to electronic structure.

    a)   The second period has eight elements in it.   (4)

    b)   There are fourteen lanthanides in the sixth period, and fourteen actinides in the 7th.   (4)

c)   The atoms of the elements show an increase in size going down a group and a decrease in size across a period.   (4)

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6)   The following question concerns solutions and titrations.
  a)   i)   What is meant by "making up to the mark" in a volumetric flask?   (2)

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      ii)   What is meant by the term *concordant*, as in "concordant titres"?   (1)

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      iii)   What is meant by the term "deliquescent"? Give one example of a deliquescent substance and explain why a solution of known molarity cannot be made from it by weighing it out and making up to the mark in a volumetric flask.   (3)

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  b)   25.0 mL aliquots of 0.102 M sodium hydroxide solution were titrated with dilute sulfuric acid. The mean of three concordant titres was 23.06 mL. Write the chemical equation for the reaction and calculate the molarity of the sulfuric acid.   (5)