

**UNIVERSITY OF VICTORIA
FINAL EXAMINATION, DECEMBER 10, 2010**

CHEMISTRY 101 Fundamentals of Chemistry I

Name: _____
(**SURNAME FIRST** in **CAPITAL LETTERS**, please)

Student number: V00

Time: **This is a 3 hour exam.**

Your instructor: (Please check one)

Pages: **16** (including this cover page)
+ data sheet (inside)
+ optical sense sheet (bubble sheet)

_____ A01 CRN13754 *Dr. P. Coddling*
_____ A02 CRN13755 *Dr. A. Sirk*
_____ A03 CRN13754 *Dr. S. Briggs*

Students **must count the number of pages** in this examination paper before starting to write the exam. **Report** any discrepancy **immediately** to one of the instructors in the room.

Answer Part I on the optical sense sheet. There are 35 multiple choice questions worth 70 marks.
Answer Part II on this examination paper. There are 12 written answer questions worth 65 marks.
TOTAL MARKS AVAILABLE = 135

HAND IN THIS ENTIRE PAPER AS WELL AS YOUR OPTICAL SENSE FORM. MAKE SURE YOUR NAME AND STUDENT ID ARE ENTERED ON BOTH.

(Only the SHARP EL-510R calculator is permitted.)

Question	MARK	Question	MARK
1. (9)		9. (8)	
2. (2)		10. (6)	
3. (6)		11. (6)	
4. (3)		12. (3)	
5. (8)		TOTAL for written part (65)	
6. (4)		Multiple Choice (70)	
7. (2)		RAW SCORE (135)	
8. (6)		EXAM (%)	

PART I. Multiple Choice. Answer on the computer bubble sheet supplied. USE A SOFT PENCIL.Select the **best** response for each question below.Multiple Choice:

- An electron is travelling with a velocity of 1.21×10^6 m/s. The uncertainty in measuring its velocity is 10.0 m/s. What is the minimum uncertainty in measuring its position (in meters).
 - 2.09×10^{10} m
 - 5.78×10^{-6} m
 - 4.23×10^{-11} m
 - 1.93×10^{10} m
 - 4.78×10^{-11} m
- What is the total energy (in kJ) of a mole of photons of frequency 3.13×10^{11} s⁻¹?
 - 2.08×10^{-22}
 - 2.08×10^{-25}
 - 1.25×10^5
 - 125
 - 0.125
- Which of the following statements about electrons is **INCORRECT**?
 - Electrons can be diffracted by a crystal.
 - Increasing the speed of an electron increases its wavelength.
 - An electron's position and momentum cannot be known at the same time.
 - An electron has a smaller mass than a neutron.
 - An electron that is farther, on average, from the nucleus of a hydrogen atom is higher in energy than an electron that is, on average, closer to the nucleus.
- Which of the following statements about a ground state rubidium (Rb) atom is **INCORRECT**?
 - There are 18 electrons with $n = 3$.
 - There are at least 18 electrons with $m_s = -1/2$.
 - There are 2 electrons with $m_\ell = -2$.
 - There are 9 electrons with $\ell = 1$.
 - There are 9 s-electrons.
- Which electron configuration is **INCORRECT** for the ground state atom listed?
 - Ga [Ar] $4s^2 3d^{10} 4p^1$
 - Pb [Xe] $6s^2 4f^{14} 5d^{10} 6p^2$
 - Ni [Ar] $4s^2 3d^7$
 - Ca [Ar] $4s^2$
 - I [Kr] $5s^2 4d^{10} 5p^5$

7. The electronic configuration for the ground state of the cobalt $3+$ ion (Co^{3+}) is:

- A) $[\text{Ar}] 3d^7 4s^2$
- B) $[\text{Ar}] 3d^6$
- C) $[\text{Ar}] 3d^3 4s^3$
- D) $[\text{Ar}] 3d^4 4s^2$
- E) $[\text{Ar}] 3d^5 4s^1$

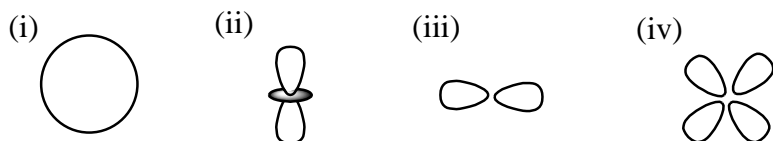
8. Which one of the following is not a valid value for the magnetic quantum number (m_l) of an electron in a 5d subshell?

- A) 3
- B) 0
- C) -1
- D) 1
- E) 2

9. An indium (In) atom has 49 electrons. Electrons in which subshell of the ground state In atom experience the lowest effective nuclear charge (Z_{eff})?

- A) 5p
- B) 3d
- C) 6s
- D) 3p
- E) 4d

10. Which sketch or sketches represent an orbital with an azimuthal quantum number (ℓ) equal to 1?

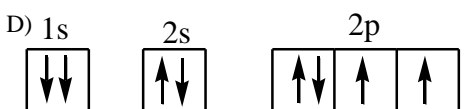
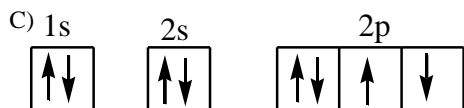
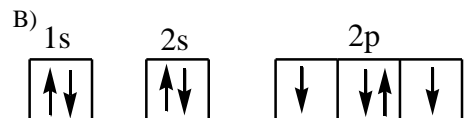
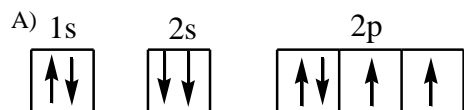


- A) i and ii
- B) ii only
- C) iii only
- D) iv only
- E) ii and iv

11. Judging from the known trends in the periodic table, which of the following has the smallest first ionization energy?

- A) F
- B) Na
- C) Al
- D) Cl
- E) Ar

12. Which one of the following represents the ground state of an oxygen atom?



E) None of the above configurations is correct.

13. Electrons in the 1s subshell are much closer to the nucleus in Ar than in He due to the larger _____ in Ar.

- A) paramagnetism
- B) diamagnetism
- C) azimuthal quantum number
- D) atomic radius
- E) nuclear charge

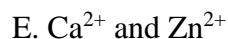
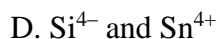
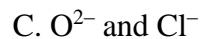
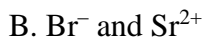
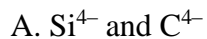
14. The atomic radius generally increases as we move _____.

- A) up a group (column) and from right to left across a period (row)
- B) up a group and from left to right across a period
- C) down a group and from left to right across a period
- D) down a group; the period position has no effect
- E) down a group and from right to left across a period

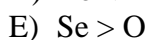
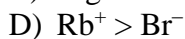
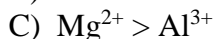
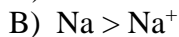
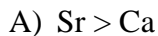
15. The group of atoms in which ALL members have negative electron affinities is:

- A) N, He, Ne
- B) Li, Be, B
- C) N, O, F
- D) F, Cl, Br
- E) Li, Mg

16. Which of the following pairs of ions are isoelectronic?



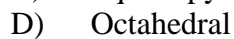
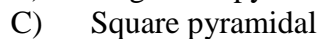
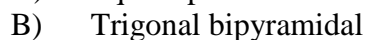
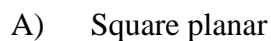
17. If $A > B$ means that the radius of A is greater than the radius of B, which of the following is INCORRECT?



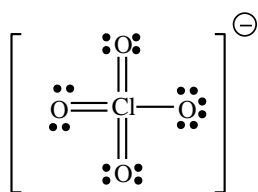
18. Which one of the following molecules is polar? (*i.e.* Which has a non-zero net molecular dipole?)



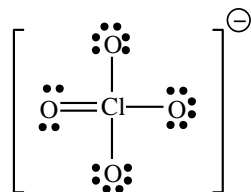
19. Consider the XeF_4 molecule. The molecular geometry (shape) is?



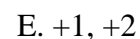
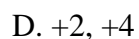
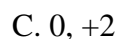
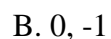
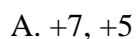
20. Here are two resonance structures for the perchlorate ion, ClO_4^- . The formal charges on the chlorine atoms in structures (i) and (ii) are (respectively)?



(i)



(ii)

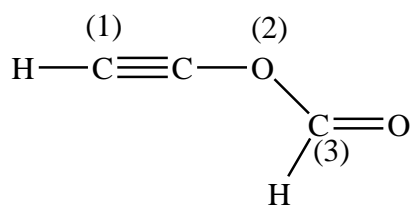


24. Which of the following pairs has the ionic compound with larger (more negative) lattice energy listed first?
- A. CaO, BaO
 - B. SrS, CaS
 - C. CsCl, BaS
 - D. CaS, CaO
 - E. CsCl, LiCl

25. Consider the following molecule.

The correct hybridizations of the atomic orbitals on the atoms labeled 1, 2 and 3 are (respectively)?

- A) sp^2 , sp^2 , and sp^2
- B) sp^2 , sp^3 , and sp^2
- C) sp , sp^2 , and sp^2
- D) sp , sp^3 , and sp^2



- E) sp , sp^3 , and sp^3

26. The electron domain geometry of SO_2 is?

- A) Tetrahedral
- B) Octahedral
- C) Trigonal pyramidal
- D) Trigonal planar
- E) Bent

27. Consider doping the semiconducting material germanium (Ge). Addition of a very small amount of which element would make the germanium a better electrical conductor?

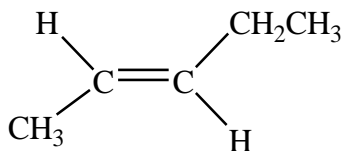
- A) Gallium
- B) Phosphorus
- C) Arsenic
- D) Aluminum
- E) Any of the above

29. Which of the following statements concerning the BeCl_2 molecule is INCORRECT?

- A) The central atom in this molecule has two sp hybrid orbitals.
- B) The central atom in this molecule does not obey the octet rule.
- C) The molecule is linear with a bond angle of 180° .
- D) This molecule is polar.
- E) The $\text{Be}-\text{Cl}$ bonds are polar.

31. The correct systematic (IUPAC) name for the following molecule is:

- A) *cis*-3-pentene
- B) *trans*-2-pentene
- C) *trans*-2-propene
- D) *cis*-2-pentene
- E) *cis*-1-methyl-1-butene

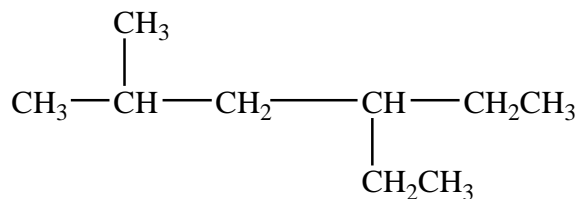


32. Which of the following statements concerning intermolecular forces is INCORRECT?

- A) London dispersion forces operate between all molecules.
- B) Hydrogen bonding is a special type of intermolecular attraction between the hydrogen atom in a polar bond and an unshared electron pair on a nearby electronegative atom.
- C) London dispersion forces account for the fact that molecular iodine, I_2 , is a solid.
- D) The higher boiling point of water compared to that of H_2S is due to London dispersion forces.
- E) In order for solid paraffin wax, an alkane, to be vaporized, enough energy must be supplied to overcome the London dispersion forces between molecules.

33. The correct name for the compound below is:

- A) 3-ethyl-5-methylhexane
- B) 3-isobutylpentane
- C) 4-ethyl-2-methylhexane
- D) 2-ethyl-4-methylhexane
- E) 1,1-diethyl-3-methylbutane



34. Consider the molecule in question 33 above and evaluate the following statement:
This molecule is chiral.

- A) True
- B) False

35. Which of the following statements concerning crystalline solids and modern materials is INCORRECT?

- A) Graphite and diamond are examples of a covalent-network solid.
- B) Nylon is a naturally occurring polymer.
- C) Polyethylene is an addition polymer.
- D) Vulcanization of natural rubber cross-links the polymer molecules with sulfur atoms.
- E) Sodium chloride is an ionic solid.

PART II. Written Answer Questions. Answer directly on this examination paper. You may use the back of the examination paper pages if you require more space.

[9 MARKS]

1. Three elements have the following electron configurations; $1s^22s^22p^63s^23p^64s^2$, $1s^22s^22p^63s^23p^64s^23d^{10}4p^6$, and $1s^22s^22p^63s^23p^64s^23d^{10}4p^65s^1$. The first ionization energies of these three elements (but not necessarily in the same order) are 1351, 403, and 590 kJ mol^{-1} . Their atomic radii (also not necessarily in the same order) are 248 pm, 110 pm, and 197 pm. Identify these three elements, and match the appropriate values of ionization energy and atomic radius to each configuration.

USE THE TABLE BELOW TO ENTER YOUR ANSWERS.

Electron Configuration	Name or Symbol of Element	First Ionization Energy kJ mol^{-1}	Atomic Radius (pm)
$1s^22s^22p^63s^23p^64s^23d^{10}4p^65s^1$			
$1s^22s^22p^63s^23p^64s^23d^{10}4p^6$			
$1s^22s^22p^63s^23p^64s^2$			

[2 MARKS]

2. Write the complete ground state electron configuration for copper (Cu). Do NOT use the condensed electron configuration representation involving a noble gas core.

[6 MARKS]

3. Draw all the Lewis structures that OBEY THE OCTET RULE for selenium dioxide (SeO_2) and selenium trioxide (SeO_3). Which molecule is predicted, by consideration of these structures, to have the shorter Se—O bonds? Explain briefly.

[3 MARKS]

3. A student was given four small bottles containing white or gray powdery substances and labeled Q, R, S and T. The student was told that the four samples could be silver, table sugar, sodium chloride or alumina (Al_2O_3 , a covalent network solid). The student performed a number of tests and obtained these results:
- (a) Sample Q and R dissolve in water readily. The other two do not dissolve at all.
 - (b) Sample Q melts easily over gentle heat. The other three do not melt except at very high temperatures.
 - (c) A small pile of substance S conducts electricity. The other three substances do not.

Identify the samples.

Sample Q is _____

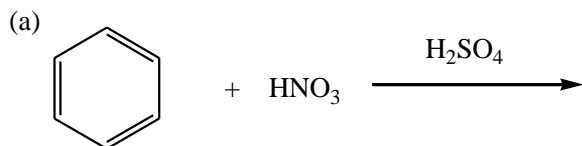
Sample R is _____

Sample S is _____

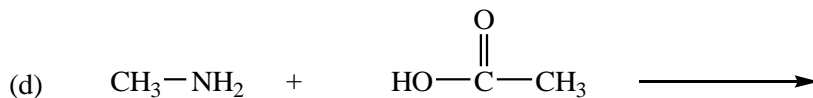
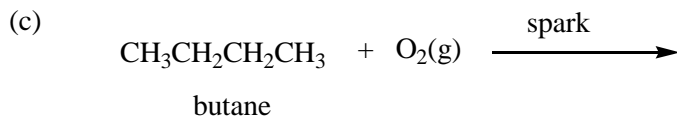
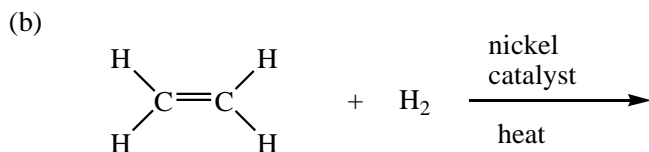
Sample T is _____

[8 MARKS]

4. For each reaction below draw the structure of the missing product molecule(s). A balanced equation is not required. If you predict no reaction then you must say so. i.e. N.R. All major products must be



shown.



[4 MARKS]

5. (a) If the core electrons were completely effective at shielding the valence electrons from the full charge of the nucleus and if valence electrons provide no shielding for each other, what would be the effective nuclear charge (Z_{eff}) acting on the valence electrons in an atom of aluminum (Al)?

Be sure to show how you arrive at your answer.

(b) Detailed calculations show that the effective nuclear charge acting on the valence electrons of aluminum is 4.0. Briefly account for any difference between this value and the value you calculated in part (a) above.

(c) If you take away the most easily removed electron from an aluminum atom (i.e. ionization), which orbital will it come from? Explain your choice briefly.

[2 MARKS]

6. Chemists often use the octet rule to explain the behavior of elements and compounds in chemical reactions. State the octet rule.

[8 MARKS]

7. (a) The N_2O molecule is linear and has connectivity NNO. Draw all the Lewis structures for this ion that obey the octet rule. Show each bonding pair of electrons as a line (—), and each non-bonding pair as dots (:). Write the formal charge beside each atom (in all structures) where it is not equal to zero.

[5 MARKS]

- (b) Nitric oxide, NO, is an important signaling molecule in biological chemistry, and the work on this molecule resulted in the awarding of the 1998 Nobel Prize in Physiology and Medicine. Nitric oxide is a radical, meaning that it has an unpaired electron. Draw the two Lewis structures for this molecule. Explain briefly how you would decide which structure is the better description of what the real NO molecule is like, and circle it. [3 MARKS]

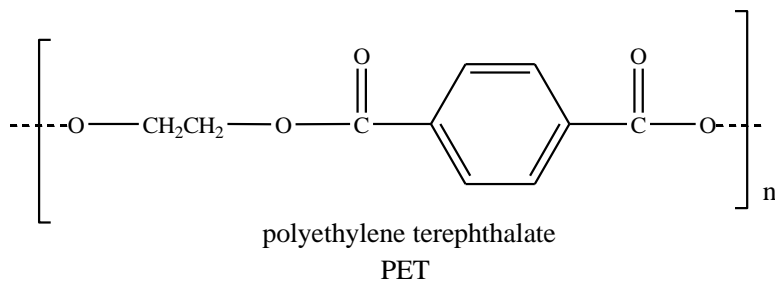
[8 MARKS]

9. Complete the table below.

	Any one valid Lewis Structure	Molecular geometry (Name and draw the 3-D shape of the molecule.)	Orbital Hybridization of central atom	Net molecular dipole moment? If yes, show the direction of the net dipole on a sketch of the molecular shape.
NO_3^-				
ClO_3				

[6 MARKS]

10. The structure of the polymer polyethylene terephthalate is shown below:

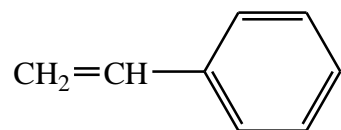


[4 MARKS]

- (a) Draw the structures of the two monomers that are used to make polyethylene terephthalate, which is a condensation polymer.

[2 MARKS]

- (b) Draw the structure of the polymer that results when vinyl benzene (structure below) is polymerized.
Show at least 2 repeating units.



[6 MARKS]

11. Draw three constitutional (structural) or geometric isomers of C_3H_6O . Show all atoms.

[3 MARKS]

12. Circle TRUE or FALSE after each of the following statements.

- (a) All other factors being the same, London dispersion forces between molecules increase with the number of electrons in the molecule. TRUE or FALSE
- (b) For molecules of roughly the same molar mass and shape, dipole-dipole interactions are stronger than London dispersion forces. TRUE or FALSE
- (c) The boiling points of the noble gases decrease as you go down the group (column) in the periodic table. TRUE or FALSE

END