NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

DEPARTMENT OF APPLIED CHEMISTRY
END OF SEMESTER EXAMINATIONS - DECEMBER 2002
INORGANIC CHEMISTRY I - SCH1101
TIME: 3 HOURS

INSTRUCTIONS TO CANDIDATES

Answer **ALL** questions from Section A and **ANY THREE** from Section B.

Periodic Tables Required

Planck's Constant h = 6.626 x 10^{-34} J s Velocity of light c = 2.998 x 10^{8} m s^{-1}
Charge on the electron e = 1.602 x 10^{-19} C

SECTION A

1. (a) Specify the set of quantum numbers used to describe an electron in an atom, and state what values of each are possible. (8 marks)

   (b) State the Exclusion Principle in a form relevant to atomic structure. Show how it leads to the conclusion that in a given shell there can only be two s, six p and ten d electrons. (5 marks)

2. The Li^{2+} ion has a Lyman series at 740747 cm^{-1}, 877924 cm^{-1}, 925933 cm^{-1}, and beyond.

   (a) Show that the energy levels are of the form $-hcR/n^2$. (6 marks)

   (b) Calculate the value of R for this ion. (4 marks)

3. Using VSEPR Theory, predict the geometry of the following interhalogen species:

   (a) BrF_3 , (b) IF_5 , (c) IBr_2^- (9 marks)

4. Show how the electronic structure of O_2^- and O_2^{2-} can be inferred from the structure of O_2. Explain why O_2^- has a stronger bond than O_2^{2-}. (7 marks)

5. The ionic radius of O^{2-} is 140 pm. Which of the following Group II ions would be predicted to form 4-, which 6- and which 8-co-ordination in their oxides?
   Mg^{2+} 72 pm, Ca^{2+} 100 pm, Sr^{2+} 116 pm, Ba^{2+} 136 pm. (6 marks)

odd no's

6. Draw the possible Kekule' structures for naphthalene $C_{10}H_8$, which consists of two fused benzene rings. Identify the four types of non-equivalent C-C bonds in this molecule, and predict the bond order of each based on the assumption that each Kekule' structure has equal weight in forming the resonance hybrid. (9 marks)

SECTION B

7. (a) Using molecular orbital theory, derive the electronic configurations and bond orders of the homonuclear diatomic molecules C_2, N_2, O_2, and F_2. (9 marks)

(b) Which of the above molecules would be stabilised by (i) the removal of an electron to form X_2^+, (ii) the addition of an electron to form X_2^-? Explain. (6 marks)

8. The bond angle in water, H_2O, is 104.5^O.

(a) Explain this observation using VSEPR theory. (5 marks)

(b) Using a sketch, predict the orientation of the dipole moment in the water molecule. If the magnitude of the dipole moment is 6.17×10^{-30} C m and the O-H bond length 103 pm, estimate the bond dipole and the fractional charges on the atoms. (10 marks)

9. (a) The metallic radii of molybdenum, Mo, and tungsten, W, are both 136 pm. How does this observation differ from the normal behaviour of the atomic radius within a Group, and what is the explanation? (3 marks)

(b) If elemental Mo and W both have body-centred cubic crystal structures, calculate the unit cell edge length a for each. (5 marks)

(c) Show that the density of Mo is 10.3 g cm^{-3}, and calculate the density of W. (7 marks)

even no's

10. In the Huckel approximation the π-electron energies of a homonuclear ring system are given by the formula

$$E_j = \alpha + 2\beta \cos(2\pi j/n)$$

where $j = 0, \pm1, \pm2 \ldots n/2$ n even,
$\ldots \pm(n-1)/2$ n odd,

n is the ring size, and α and β have their usual meanings.

(a) Sketch the energy level diagrams for n = 4, 5, 6, 7 and 8. (5 marks)

(b) Calculate the delocalisation energy (if any) of the following cyclic species, and state which would be considered aromatic:-
(i) C_4H_4, (i) $C_5H_5^-$,(i) C_6H_6,(i) $C_7H_7^+$,(i) C_8H_8. (10 marks)

11. (a) Explain the theoretical Born-Mayer expression for the lattice energy of an ionic crystal. Illustrate how the Madelung constant arises by writing down the first three terms for the sodium chloride crystal structure. (8 marks)

(b) Show how the lattice enthalpy is determined experimentally by sketching the Born-Haber cycle for NaCl. (7 marks)

END OF QUESTION PAPER!!!!

odd no's