THOMPSON RIVERS UNIVERSITY
OPEN LEARNING

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ANSWER KEY

PRACTICE EXAMINATION

CHEM 1503 • CHEMICAL BONDING AND ORGANIC CHEMISTRY

PART I *(30 marks total)*

(3 marks) 1. a. Aluminum dichromate b. Titanium(IV) carbonate
c. Iodine tribromide d. Sodium hydrogen carbonate or sodium bicarbonate

(3 marks) 2. $$\Delta E = R_H\left(\frac{1}{n_i^2} - \frac{1}{n_f^2}\right) = 2.18\times10^{-18}\,\text{J}\left(\frac{1}{5^2} - \frac{1}{3^2}\right)$$

$$= -1.55\times10^{-19}\,\text{J}$$ (energy released, therefore light is emitted)

$$\lambda = \frac{ch}{\Delta E} = \frac{3.00\times10^{8}\,\text{m}\cdot\text{s}^{-1}\times\ 6.63\times10^{-34}\,\text{J}\cdot\text{s}}{1.55\times10^{-19}\ \text{J}}$$

$$= 1.28\times10^{-6}\,\text{m}$$

$$= 1280\ \text{nm}$$

(This wavelength is in the infrared wavelength range, so the transition is part of the Paschen series.)

(3 marks) 3. a. $\ell = 0$ or $n = 2$
b. $m_S = \frac{1}{2}$
c. correct
d. $\ell = 3$

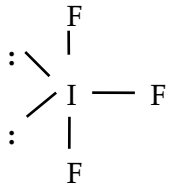
(3 marks) 4. a. i. Al because it is in the same period but has a lower effective nuclear charge than Cl (sometimes called periodic contraction).

ii. Tl because it is in the same group, but has additional shells of electrons (n value has increased) which reside further from the nucleus than for Al.

b. X^{3+} since you see a large jump in IE when removing the 4th electron.

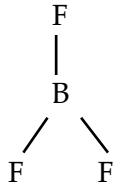
(3 marks) 5.

Iodine trifluoride:



T-shaped: has dipole (since not symmetrical)

Boron trifluoride:



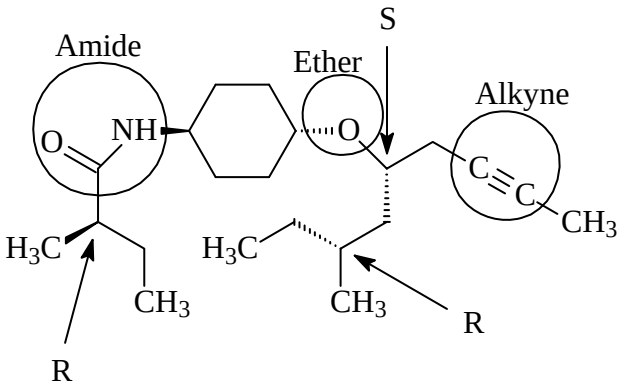
Trigonal planar: no dipole (since symmetrical)

Symmetry affects whether or not a substance has a dipole.

(3 marks) 6.

Molecule A van der Waals intermolecular forces (IMF)
Molecule B Hydrogen bonding
Molecule C Dipole-dipole
A has the weakest IMF and so the lowest boiling point, followed by C, and then B.

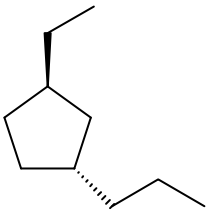
(3 marks) 7.



(3 marks) 8. a. i. 5-ethyl-3-methyloctane

ii. 3-bromo-4-ethyl--5*S*-methyl-3*Z*-heptene

b.

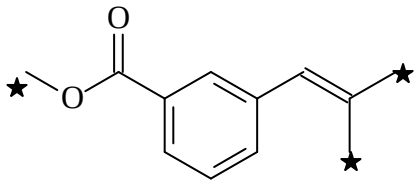


or equivalent

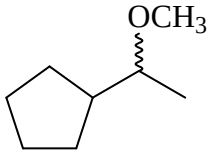
(3 marks) 9. a. 28, careful to count all the H's and the first bond of multiple bonds

b. 5

c. sp^3 indicated with a star, all other carbons are sp^2



(3 marks) 10. a. Racemic product



b. S_N1, since secondary alkyl halide with poor nucleophile, protic solvent

c. I^-

d. CH_3OH

e. Protic

PART II *(70 marks total)*

(7 marks) 1. a. i. Moles of HCl spilled = volume × concentration / molar mass
= 500. mL × 35 g/100 mL × 1 mol/36.45 g
= 4.80 mol HCl

Moles of Na_2CO_3 needed to neutralize HCl
= mol HCl × 1 mol Na_2CO_3 /2 mol HCl
= 2.40 mol Na_2CO_3 needed

Moles of Na_2CO_3 added = mass / molar mass
= 195 g × 1 mol/106.01 g
= 1.84 mol Na_2CO_3

Insufficient Na_2CO_3 has been added. You would need
2.40 mol to neutralize the acid; but only 1.84 mol have been added.

ii. g NaCl formed =
mol Na_2CO_3 × 2 mol NaCl /1 mol Na_2CO_3 × molar mass NaCl
= 215 g NaCl

215 g of NaCl have been formed. Na_2CO_3 is the limiting reagent.

(7 marks) b. i.

$$\text{Moles of C} = 2.2\text{g } CO_2 \times \frac{1\text{mole } CO_2}{44.01\text{g}} \times \frac{1\text{mole C}}{1\text{mole } CO_2}$$
$$= 0.04999 \text{ moles C}$$

$$\text{Moles of H} = 0.9\text{g } H_2O \times \frac{1\text{mole } H_2O}{18.01\text{g}} \times \frac{2\text{mole H}}{1\text{mole } H_2O}$$
$$= .0.9994 \text{ moles H}$$

$$\text{g of O} = 1.4\text{g} - \left(0.04999 \text{ moles C} \times \frac{12.01\text{g}}{1\text{mole C}}\right) - \left(0.09994 \text{ moles H} \times \frac{1.008\text{g}}{1\text{mole H}}\right)$$
$$= 1.4\text{g} - 0.60\text{g} - 0.10\text{g}$$
$$= 0.7\text{g O}$$

$$\text{Moles of O} = 0.7\text{g O} \times \frac{1\text{mole}}{15.999\text{g}} = 0.04375 \text{ mole O}$$

$$\text{empirical formula} = C_{0.04999}\, H_{0.09994}\, O_{0.04375}$$
$$= C_{1.1}\, H_{2.2}\, O_1$$
$$= CH_2O$$

ii. $C_2H_4O_2 + 2O_2 \longrightarrow 2CO_2 + 2H_2O$

(4 marks) 2. a. The definition of electron affinity given in the text refers to the negative of the energy change when an electron is accepted by an atom in the gaseous phase to form an anion. Under these conditions, F^- is isoelectronic with Ne and thus has a more "stable" electron configuration than O^-; fluorine would release more energy when accepting an electron, hence fluorine has the higher electron affinity.

(3 marks) b. Br^- and Rb^+ : $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^6$

(3 marks) c. $n = 3;\ \ell = 1;\quad m_\ell = 1, 0, -1;\quad m_S = \pm\frac{1}{2}$

$n = 2;\ \ell = 1;\quad m_\ell = 1, 0, -1;\quad m_S = \pm\frac{1}{2}$

(4 marks) d. Nitrogen cannot expand its octet since there are no 2*d* electrons. Arsenic can expand its octet using 4*d* electrons. Thus, it is predicted that nitrogen pentabromide cannot exist but arsenic pentabromide can.

3. Determine the electron configuration or draw molecular orbital diagrams to answer parts a and b.

(4 marks) a. V^{4+} and F_2^+ each contain an unpaired electron and so are paramagnetic.

(3 marks) b. i. Ne_2^+, since Ne_2 does not exist

ii. Ethene, since ethyne has a higher bond order of 3 (versus 2)

iii. N_2H_4, since N_2 has a higher bond order of 3 (versus 1)

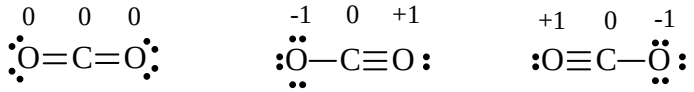
(4 marks) c. NO_3^- : trigonal planar sp^2

XeF_4 : square planar sp^3d^2

CO_2 : linear sp

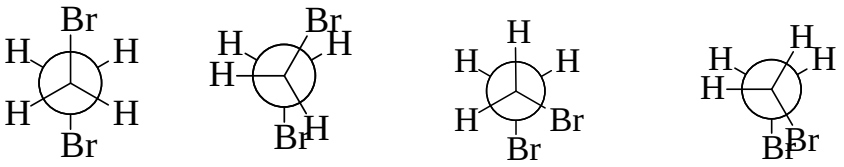
IBr_2^- : linear sp^3d

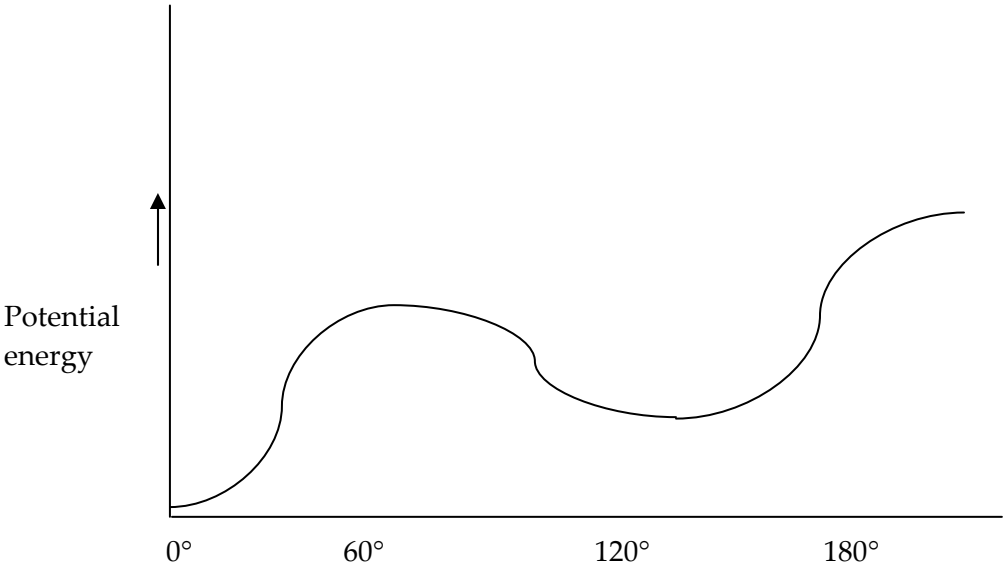
(3 marks) d.



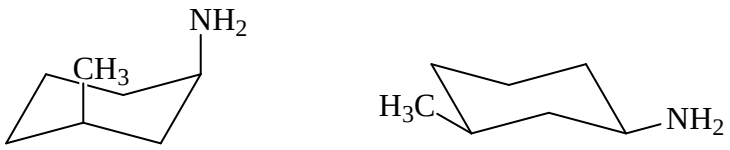
The hybrid with no formal charges is most likely to predominate.

(7 marks) 4. a. staggered anti eclipsed staggered gauche fully eclipsed





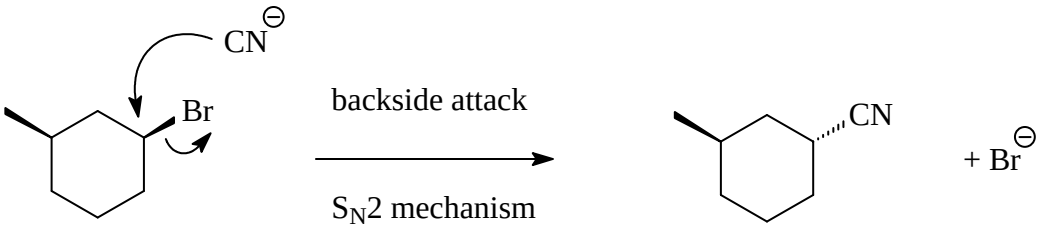
(7 marks) b.



The second molecule is the most stable with all substituents equatorial. This avoids the higher energy, less stable 1,3 diaxial interactions between the amino and methyl groups.

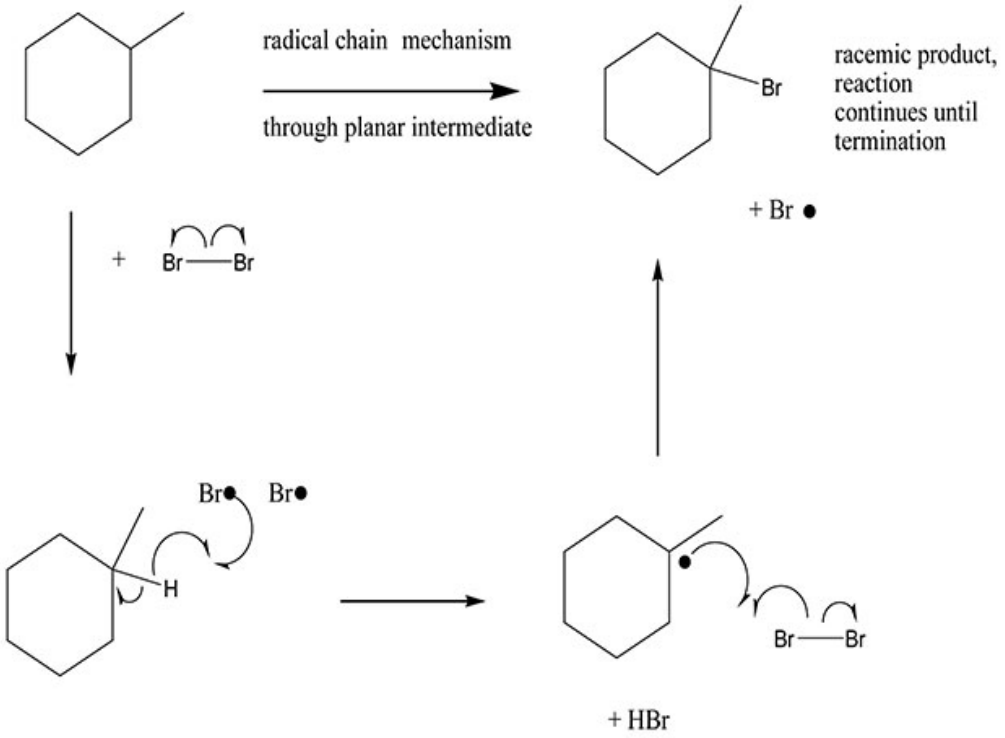
(4 marks) 5. a. i. NaCN in acetone (or any other aprotic solvent)

ii.



(4 marks) b. i. Br_2 , *hv*

ii.



(6 marks) c. i. H_2O

ii.