C/D

Name: Group: G/H Student Number:

CH101 GENERAL CHEMISTRY MID TERM EXAMINATION
24 APRIL 2003 TIME ALLOWED: 1 HOUR

1. Calculate the molarity of a solution containing 1.013 g of sodium hydroxide (NaOH) in 250 mL of solution. Show working. [molar masses (g mol^{-1}): H = 1.008, O = 15.999, Na = 22.990]

M_r NaOH = 39.997 g mol^{-1}
No. of moles of NaOH in 250mL = $\frac{1.013}{39.997}$
Molarity = $\frac{1.013}{39.997} \times \frac{1000}{250}$ (in 1L) = 0.101 M

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2. A compound of molar mass 133.405 g mol^{-1} was found to contain 18.00% C, 2.28% H and 79.73% Cl. Determine the molecular formula of X, showing all working. [molar masses (g mol^{-1}): H = 1.008, C = 12.011, Cl = 35.453]

$\%C = 18.00 = \frac{n \times 12.011 \times 100}{133.405} \Rightarrow n = 2$
$\%H = 2.28 = \frac{n \times 1.008 \times 100}{133.405} \Rightarrow n = 3$
$\%Cl = 79.73 = \frac{n \times 35.453 \times 100}{133.405} \Rightarrow n = 3$

$C_2H_3Cl_3$

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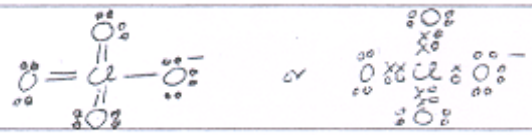
3. Draw a Lewis diagram for the perchlorate ion (ClO_4^-). [Cl – group 7, O – group 6]


or

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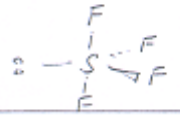
4. Use the VSEPR theory to determine the shape of the SF_4 molecule. Show working. [S – group 6, F – group 7]

SN = 4 + 1 = 5 ⇒ trigonal bipyramid
Best arrangement is with lone pair in equatorial position ("See-Saw") Distorted.



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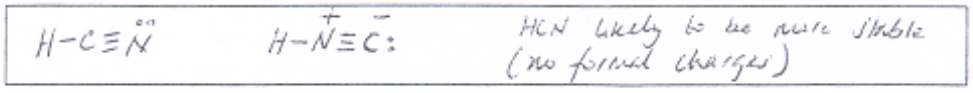
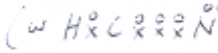
5. Write down Lewis diagrams for hydrogen cyanide (HCN) and hydrogen isocyanide (HNC). Which is likely to be the more stable molecule? [C – group 4, N – group 5]


HCN likely to be more stable (no formal charges)

(or ) (or)

6. If the H-Cl bond length is 1.28 Å and the HCl molecule has a dipole moment of 1.109 D. determine the percentage ionic character of the H-Cl bond. Show working.

$\mu = \frac{RS}{0.2082}$; $1.109 = \frac{1.284 \times \delta}{0.2082}$

$\delta = 0.18 \Rightarrow$ HCl bond is 18 % ionic

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7. Calculate the root mean square speed (u_{rms}) for oxygen molecules at 298 K. Show working. [R = 8.315 Kg m^2 s^{-2} mol^{-1} K^{-1}; molar mass of O = 15.999 g mol^{-1}]

$M(O_2) = 2 \times 15.999 = 31.998\ g\,mol^{-1} \equiv 0.031998\ Kg\,mol^{-1}$

$u_{rms} = \sqrt{\frac{3RT}{M}} = \sqrt{\frac{3 \times 8.315 \times 298}{0.031998}} = 482\ ms^{-1}$

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8. Explain the difference in the van der Waals constants a and b for the following gases.

Gas	a / atm L^2 mol^{-2}	b / L mol^{-1}
Methane	2.253	0.04278
Ammonia	4.170	0.03707
Water	5.464	0.03049

b ⇒ repulsive forces ⇒ molecular volume : $CH_4 > NH_3 > H_2O$

a ⇒ attractive forces ⇒ CH_4 London type, NH_3 hydrogen bonding, H_2O stronger hydrogen bonding

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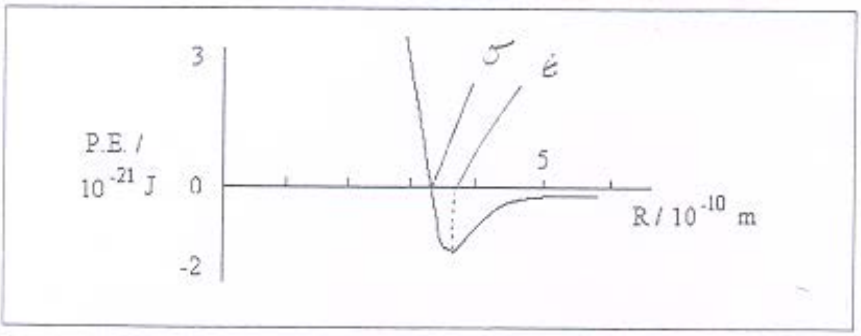
9. Locate the constants ε and σ on the following potential energy diagram.



(see over)

What kind of intermolecular forces does this diagram illustrate?

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(Attractive) London forces and repulsive forces

10. State which attractive intermolecular forces are likely to predominate in associations among molecules in the following substances:
(a) F_2 (solid), (b) SO_2 (liquid), (c) HF (liquid), (d) NH_4Cl (solid).

(a) London (b) dipole–dipole
(c) hydrogen bonding (d) ionic

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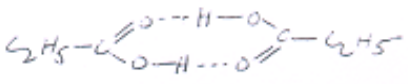
11. Draw a structure for the propionic acid ($C_2H_5CO_2H$) dimer.



This structure predominates in solutions of propionic acid in non-polar solvents, but not in dilute aqueous solution. Explain why.

In dilute aqueous solution, dimers broken up by stronger hydrogen bonding to H_2O. There is also dissociation (ionization)

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12. List the following substances in order of increasing boiling point:
SO_2, He, HF, CaF_2, Ar.

$He < Ar < SO_2 < HF < CaF_2$

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13. At 20° C, the vapor pressure of benzene is 0.0987 atm and the vapor pressure of toluene is 0.0289 atm. If equal amounts (equal number of moles) of benzene and toluene are mixed to form an ideal solution, calculate the mole fraction of benzene in the vapor at equilibrium with the solution.

p(benzene) = $0.50 \times 0.0987 = 0.0494$ atm
p(toluene) = $0.50 \times 0.0289 = 0.0140$ atm
} total 0.0634 atm

For vapor X(benzene) = $\frac{p(\text{benzene})}{p(\text{total})}$

$= \frac{0.0494}{0.0634} = 0.774$

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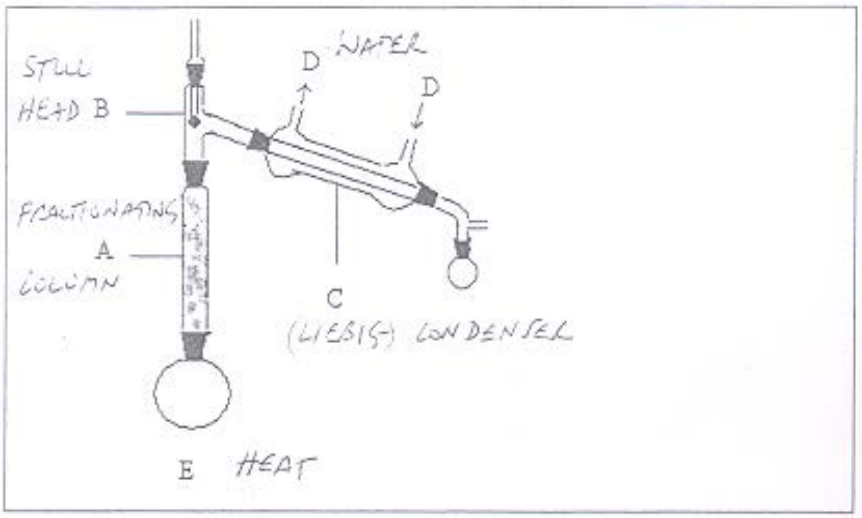
14. Identify the components A –D in the distillation apparatus diagram below.



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15. Classify each of 1 – 5 as (a) an aerosol, or (b) an emulsion, or (c) a sol:
1. gold in water, 2. mayonnaise, 3. smoke, 4. opal, 5. skin ointment.

1.	2.	3.	4.	5.
(c)	(b)	(a)	(c)	(b)

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