Name: _____   Student number: _____

Chemistry 1A03   **Test 2**   **Nov 11, 2016**

McMaster University   **VERSION 1 - SOLUTIONS**   **17:30 –19:30**

Instructors: L. Chen, L. Davis, D. Emslie, A. Hitchcock

                                                                Duration: 120 minutes

This test contains 10 sheets of paper, printed on both sides, for a total of 20 numbered pages. There are **28** multiple-choice questions appearing on pages numbered 3 to 16. Pages 17 and 18 are extra space for rough work. Page 19 includes some useful data and equations, and there is a periodic table on page 20. You may tear off the last page to view the periodic table and the data provided.

You must enter your name and student number on this question sheet, as well as on the answer sheet. Your invigilator will be checking your student card for identification.

You are responsible for ensuring that your copy of the question paper is complete. Bring any discrepancy to the attention of your invigilator.

All questions are worth 2 marks - the total marks available are 56. There is **no** penalty for incorrect answers.

BE SURE TO ENTER THE CORRECT VERSION OF YOUR TEST (shown near the top of page 1), IN THE SPACE PROVIDED ON THE ANSWER SHEET.

ANSWER ALL QUESTIONS ON THE ANSWER SHEET, IN PENCIL.

Instructions for entering multiple-choice answers are given on page 2.

SELECT ONE AND ONLY ONE ANSWER FOR EACH QUESTION from the answers **(A)** through **(E)**. **No work written on the question sheets will be marked**. The question sheets may be collected and reviewed in cases of suspected academic dishonesty.

Academic dishonesty may include, among other actions, communication of any kind (verbal, visual, *etc*.) between students, sharing of materials between students, copying or looking at other students' work. If you have a problem please ask the invigilator to deal with it for you. Do not make contact with other students directly. Try to keep your eyes on your own paper – looking around the room may be interpreted as an attempt to copy.

Only Casio FX 991 electronic calculators may be used. They must NOT be transferred between students. Use of any aids other than those provided, is not allowed.

Name: _____   Student number: _____

OMR EXAMINATION – STUDENT INSTRUCTIONS

NOTE: IT IS YOUR RESPONSIBILITY TO ENSURE THAT THE ANSWER SHEET IS PROPERLY COMPLETED: YOUR EXAMINIATION RESULT DEPENDS UPON PROPER ATTENTION TO THESE INSTRUCTIONS.

The scanner, which reads the sheets, senses the bubble shaded areas by their non-reflection of light. A heavy mark must be made, completely filling the circular bubble, with an HB pencil. Marks made with a pen will **NOT** be sensed. Erasures must be thorough or the scanner will still sense a mark. Do **NOT** use correction fluid on the sheets. Do **NOT** put any unnecessary marks or writing on the sheet.

1. On SIDE 1 (**red side**) of the form, in the top box, *in pen*, print your student number, name, course name, and the date in the spaces provided. Then you **MUST** write your signature, in the space marked SIGNATURE. **ONLY USE THE RED SIDE OF THE OMR FORM.**

2. In the second box, *with a pencil*, mark your **student number** in the space provided. If your student number does **NOT** begin with a 4, put "00" before your student number. Then fill in the corresponding bubble numbers underneath.

3. Do NOT put in a leading zero when bubbling in your **exam version number**.

4. Answers: mark only **ONE** choice from the alternatives (A,B,C,D,E) provided for each question. The question number is to the left of the bubbles. Make sure that the number of the question on the scan sheet is the same as the number on the test paper.

5. Pay particular attention to the marking directions on the form.

6. Begin answering the question using the first set of bubbles, marked "1".

1. Carbon has two stable isotopes with natural abundances of 98.93% (^{12}C) and 1.07% (^{13}C). **How many atoms** of ^{13}C are there in a 2.05 g sample of **carbon dioxide**?

   A)   3.00 ×10^{20}
   B)   1.45 ×10^{21}
   C)   9.67 ×10^{20}
   D)   6.44 ×10^{21}
   E)   1.10 ×10^{21}

MW (CO_2) = 12.011 + 2*15.999 = 44.009 g/mol
2.05 g CO_2 contains 2.05/44.009 = 4.658x10^{-2} mol
of this, 1.07% is ^{13}C ➔ there are 1.07x10^{-2}*4.658x10^{-2} = 4.9842 x 10^{-4} mol of ^{13}C
or N_A* n(^{13}C) = 6.022x10^{23}*4.9842 x 10^{-4} = 3.00x10^{20} atoms of ^{13}C

2. What **volume** (in mL) of ^{37}Cl$_2$ is required to produce 1.00 g of K^{37}Cl based on the following *unbalanced redox reaction* at 25°C and 2.00 atm.

$$Cl_2 \text{ (g)} + KOH \text{ (aq)} \rightarrow KCl \text{ (aq)} + KClO_3 \text{ (aq)} + H_2O \text{ (l)} \qquad \text{(unbalanced)}$$

   A)   88.3
   B)   96.4
   C)   98.4
   D)   154
   E)   75.4

In this redox reaction, Cl goes from O.N.= 0 in Cl_2 to O.N.= -1 in KCl and O.N.= +5 in $KClO_3$
To balance O.N of Cl on reactant and product side, need to have 5 KCl to each $KClO_3$
This requires 3 Cl_2 and 6 KOH on reactant side, with 3 H_2O needed to complete the balancing:

$$\mathbf{3}Cl_2 \text{ (g)} + \mathbf{6}KOH \text{ (aq)} \rightarrow \mathbf{5}KCl \text{ (aq)} + KClO_3 \text{ (aq)} + \mathbf{3}H_2O \text{ (l)}$$

MW (K^{35}Cl) = 39.098 + 37.0 = 76.08 g/mol   ➔   1.00 g is 1.00/76.08 = 0.01314 mol

From reaction stoichiometry, the amount of Cl_2 must be 3/5 *(n$_{K37Cl}$) = 7.8864x10^{-3} mol of Cl_2

$$V = \frac{nRT}{P} = (7.8864x10^{-3} mol)(0.08206 L.atm K^{-1} mol^{-1})(298.16K)/2.00atm$$
$$V = 96.38x10^{-3} L = 96.38 mL$$

or 96.4 mL to significant figures

3. Aluminium reacts **completely** with a platinum chloride compound according to the *unbalanced* reaction:

$$Al(s) + PtCl_x(aq) \rightarrow AlCl_3(aq) + Pt(s) \quad \text{(unbalanced)}$$
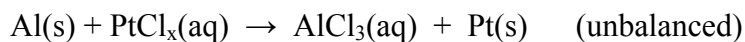
When a 1.025 g sample of platinum chloride, $PtCl_x$, is dissolved in water and reacts with an excess of aluminium, 0.594 g of platinum is produced. What is the **empirical formula** of the platinum chloride?

A) $PtCl_2$
B) Pt_2Cl_5
C) $PtCl_3$
D) $PtCl_6$
E) $PtCl_4$

The # of moles of product Pt must equal the # of moles of $PtCl_x$ reactant.
0.594 g Pt is $0.594/195.08 = 3.045 \times 10^{-3}$ mol

So we know 3.045×10^{-3} mol has a mass of 1.025 g.
The MW of the $PtCl_x$ is thus $1.025 / 3.045 \times 10^{-3} = 336.63$ g/mole (or possibly a multiple of this)

It is not possible that the formula of $PtCl_x$ is such that it contains 2 Pt, since that would have a MW > 336.63.
Thus of that MW, $(336.63 - 195.08) = 141.55$ g is Cl.
The number of Cl per Pt is thus $(141.55 / 35.453) = 3.99 \sim$ **4 Cl per Pt**. ➔ **$PtCl_4$**

Balanced Reaction is $4 Al(s) + 3 PtCl_4 (aq) \rightarrow 4 AlCl_3 + 3 Pt (s)$

4. Which **one** of the following elements is the **least electronegative** ?

A) Magnesium
B) Rubidium
C) Gallium
D) Arsenic
E) Fluorine

Electronegativity increases going up a group and from left to right across a period.
Thus the heaviest alkali metal would be the least electronegative.

5. Which **one** of the following statements regarding the transition from **n = 1 to n = 2** in a hydrogen atom is **FALSE** ?

   A) **The wavelength of light absorbed in this transition is 145 nm.**
   B) The wavelength of light absorbed in this transition is shorter than the wavelength absorbed for the transition from n = 2 to n = 3.
   C) The electron was initially in the ground state.
   D) The atom has not been ionized during this transition.
   E) The wavelength of light absorbed in this transition is not in the visible region of the electromagnetic spectrum.
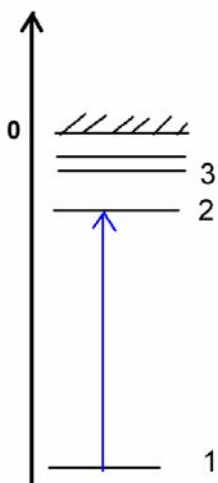
B - true - see plot
C - true
D - true
E - true - this is in the UV region

$E_{12} = (-R_H/2^2) - (-R_H/1^2) = 3R_H/4 = 0.75*(-2.179 \times 10^{-18} \text{ J})$
$= 1.634 \times 10^{-18} \text{ J}$

$$\lambda = \frac{hc}{E} = \frac{(6.6256 \times 10^{-34} \text{ J.s})(2.9979 \times 10^8 \text{ m})}{1.634 \times 10^{-18} \text{ J}} = 1.208 \times 10^{-7} m = 120.8 nm$$

A is FALSE

6. In a photoelectric effect experiment, a certain metal is struck with light of 765 nm and electrons are ejected with a velocity of $4.56 \times 10^5 \text{ m s}^{-1}$. What is the **threshold energy** of this metal, in **Joules** ?

   A) **1.65×10^{-19}**
   B) 1.15×10^{-19}
   C) 2.03×10^{-19}
   D) 1.72×10^{-19}
   E) 2.84×10^{-19}

$$E_{kin} = \frac{1}{2}hv = \frac{(9.109 \times 10^{-31} kg)(4.56 \times 10^5 m.s^{-1})^2}{2} = 9.470 \times 10^{-20} J$$

photon energy: $E = \dfrac{hc}{\lambda} = \dfrac{(6.6256 \times 10^{-34} \text{ J.s})(2.9979 \times 10^8 m.s^{-1})}{7.65 \times 10^{-7} m} = 2.597 \times 10^{-19} J$

$E_{TH} = E_{hv} - E_{kin} = 2.579 \times 10^{-19} - 9.470 \times 10^{-20} = 1.649 \times 10^{-19} J = 1.65 \times 10^{-19} J$ to S.F.

7. Which **one** of the following elements has the **greatest** magnitude of **electron affinity** ?

   A) Mg
   B) Cl
   C) S
   D) Na
   E) I

Electron affinity increases from left to right across a period and from bottom to top in a group

8. Which **one** of the following has the **smallest first ionization energy** ?

   A) Mg
   B) Al
   C) Si
   D) P
   E) S

   Na **Mg**   **Al Si P S**

First ionization energy generally increases from left to right across a period, **EXCEPT filled or ½ filled sub-shells**. The filled $3s^2$ shell of Mg stabilizes the outermost 3s electron and thereby increases the ionization energy such that the 3p outermost electron of Al is easier to ionize than the 3s electron of Mg.

Si, P, S all have larger first ionization energies than Al.

Thus **Al** has the **smallest first ionization energy**

9. The electron affinity (EA) of an iodine atom (I) can be determined by using a laser light to just ionize the iodide anion (I⁻) in the gas phase. Calculate the **wavelength in nanometers** (nm) of laser light that corresponds to the electron affinity of iodine. Data: $EA(I) = -295.2$ kJ mol⁻¹.

A) 672.9
B) 589.3
C) 434.1
D) 405.2
E) 334.8

The EA is given as a molar quantity. To evaluate wavelength it needs to be expressed per atom.

$E_{th} = (-295.2$ kJ mol⁻¹$)/(6.022 \times 10^{23}$ atom.mol⁻¹$) = 4.902 \times 10^{-22}$ kJ $= 4.902 \times 10^{-19}$ J

$$\lambda = \frac{hc}{E} = \frac{(6.6256 \times 10^{-34}\ J.s)(2.9979 \times 10^{8}\ m.s^{-1})}{4.902 \times 10^{-19}\ J} = 4.05.2 \times 10^{-7}\ m = 405.2nm$$

10. What is the **electron pair geometry** for the sulfite anion, SO_3^{2-} ?

A) Trigonal planar
B) Trigonal pyramidal
C) Tetrahedral
D) Trigonal bypyramidal
E) Octahedral

There are 2 single bonds, 1 double bond and an electron pair around S, arranged as a **distorted tetrahedron**. All 3 S-O bonds are equivalent, with a 4/3 bond order due to resonance (resonance structures not shown)
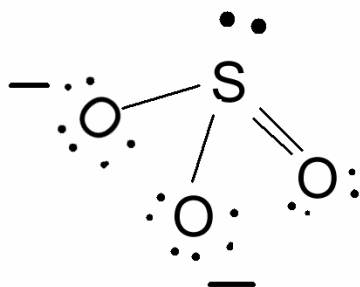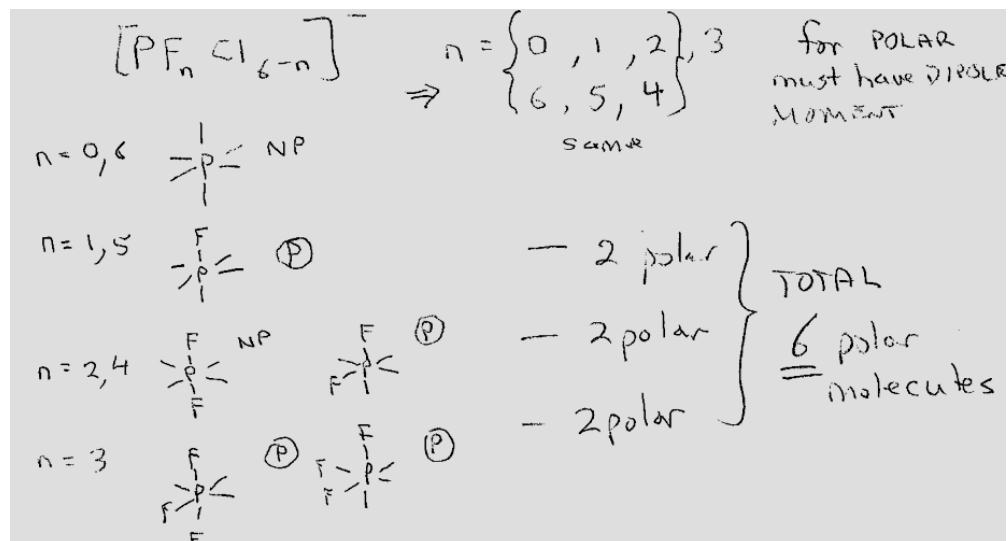
11. Which **one** of the following statements is **FALSE** ?

   A) The bond order in O_2 is higher than that in Cl_2.
   B) The bond between the carbon atoms in ethyne (C_2H_2) is stronger than that in ethene (C_2H_4).
   C) The electrons in the bonds in O_2 are less equally shared than those in the bonds in CH_4.
   D) CO binds to hemoglobin more strongly than O_2.
   E) CO has a larger dipole moment than O_2.

Statement C is false. O_2 is a non-polar molecule, in which the electrons of the bond are shared equally by the two O atoms.

12. A series of singly charged anions have the general formula $[PF_nCl_{(6-n)}]^-$ where $n = 0,1,2,3,4,5,6$. **How many unique, polar** molecules exist for this series ?

   A) 2
   B) 4
   C) 6
   D) 11
   E) 16

13. Considering the Lewis structure of selenite (SeO_3^{2-}), which **one** of the following statements is **TRUE** ?

   A) All atoms in the molecule obey the octet rule.
   B) The average formal charge on the oxygen atoms is $-1/3$.
   C) There are two resonance structures.
   D) There are 7 lone pairs of electrons in the molecule.
   E) The average Se-O bond order is 4/3.
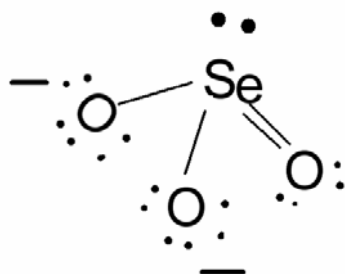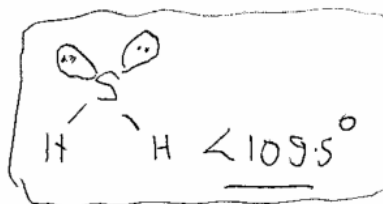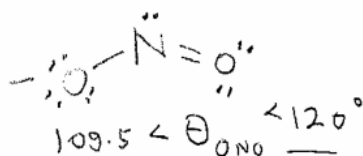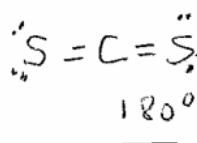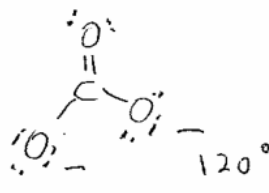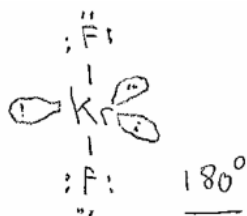

E) is TRUE
There are 3 resonance forms so each of the 3 Se-O bonds are equivalent. There are 4 bonds in total distributed over 3 Se-O bonds, for a bond order of 4/3
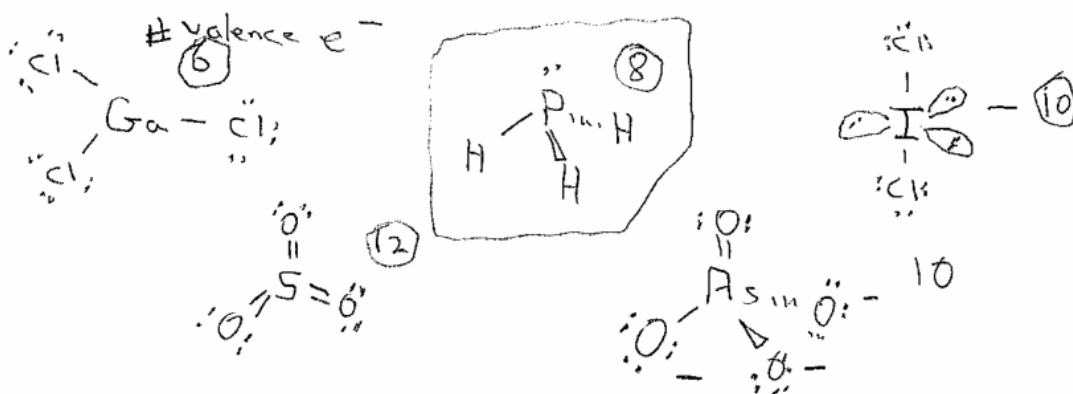
All other statements are false.

14. Which **one** of the following molecules or anions contains a **bond angle** that is **less than 109.5°** ?

   A) KrF_2
   B) CO_3^{2-}
   C) CS_2
   D) NO_2^-
   E) H₂S

15. Which **one** of the following molecules or ions has **exactly eight valence electrons** around the central atom ?

    A) $GaCl_3$
    B) PH_3
    C) ICl_2^-
    D) SO_3
    E) AsO_4^{3-}

16. Aqueous solutions of $Pb(NO_3)_2$ (10 ml, 0.020 M) and NaCl (10 ml, 0.020 M) are mixed together. **Determine Q_{sp} immediately after mixing and indicate if a precipitate will form.**
Data: K_{sp} ($PbCl_2$) = 1.6 x 10^{-5}

    A) $Q_{sp} = 1 \times 10^{-6}$ & no precipitate will form
    B) $Q_{sp} = 1 \times 10^{-4}$ & a precipitate will form
    C) $Q_{sp} = 4 \times 10^{-6}$ & a precipitate will form
    D) $Q_{sp} = 4 \times 10^{-6}$ & no precipitate will form
    E) $Q_{sp} = 1 \times 10^{-4}$ & no precipitate will form

$PbCl_2$ (s) $\rightleftharpoons$ Pb^{2+} (aq) + 2 Cl^- (aq) Q_{sp} = [Pb^{2+}(aq)]*[Cl^- (aq)]
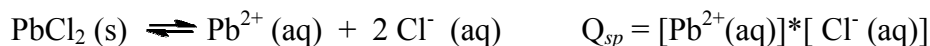
And the final volume is 20 mL, so the concentration of each ion is ½ of that if the original solution

Q_{sp} = (0.010)(0.010)^2 = **1 x 10^{-6}**

Since Q_{sp} < K_{sp} **no precipitate will form**

17. Which **one** of the following pairs of reagents, each as 0.10 M solutions, would produce **NO observable reaction** when mixed together ?

    A) Zn(CH₃COO)₂ (aq) and AgClO₄ (aq)

    B) $Pb(NO_3)_2$ (aq)   and $CuCl_2$ (aq)

    C) Na_2CO_3 (aq)   and HCl (aq)

    D) K (s)   and $Au(NO_3)_3$ (aq)

    E) Zn (s)   and HCl (aq)

A) $ZnClO_4$ and $Ag(CH_3COO)$ are both soluble. There will not be any acid-base or redox reactions.
B) $PbCl_2$ (s) will precipitate
C) This is an acid-base reaction in which CO_2 (g) will be evolved
D) K reacts violently with water to make H_2 (g)
E) Zn reacts with acid to form H_2 (g)

18. What is the **concentration (M)** of silver in a saturated solution of silver arsenate (Ag_3AsO_4) ?
    Data: $K_{sp} = 1.0 \times 10^{-22}$

    A) 1.7×10^{-6}

    B) 4.2×10^{-6}

    C) 3.4×10^{-7}

    D) 9.1×10^{-5}

    E) 1.4×10^{-4}

$Ag_3AsO_4 \rightleftharpoons 3\ Ag^+ (aq) + AsO_4^{3-}$
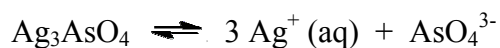
$K_{sp} = [Ag^+]^3 * [AsO_4^{3-}] \quad \rightarrow \quad 1.0 \times 10^{-22} = (3x)^3 x = 27x^4$

$$x = \left(\frac{1.0x10^{22}}{27} \right)^{1/4} = 1.39x10^{-6} \quad \text{and } [Ag^+] = 3x = 4.16x10^{-6}\ M = 4.2\ x\ 10^{-6}\ M \text{ to S.F.}$$

19. Consider the following gas phase equilibrium:

$$SF_4(g) + F_2(g) \rightleftharpoons SF_6(g)$$
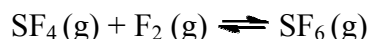
Initially, the partial pressures of each of SF_4 and F_2 are 1.00 atm in a 1.00 L vessel at 400. K. The reaction then takes place, giving a total pressure in the vessel of 1.50 atm. (note: the reaction does not go to completion and there are no side reactions). What **net change in the number of polar molecules** occurs from before, to after the reaction ?

A) 9.18×10^{21}
B) 3.22×10^{21}
C) 6.74×10^{21}
D) 1.18×10^{22}
E) 2.27×10^{20}

At equilibrium $P_{SF4} = P_{F2} = 1 - x$ and $P_{SF6} = x$
$P_{equil} = 1.5$ atm $= x + 2*(1-x) = 2- x$ ➔ $x = 2 - 1.5 = 0.50$ atm
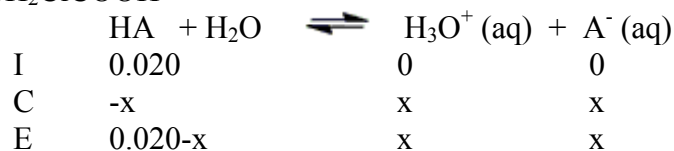Only SF_4 is polar - F_2 and SF_6 are non-polar. So change is 0.50 atm

$$\Delta n_{SF_4} = \frac{(0.50atm)(1.00L)}{(0.08206 L.atmK^{-1}mol^{-1})(400.K)} = 0.01524 mol$$

\# of molecules $= \Delta n_{SF_4} * 6.022 \times 10^{23} =$ **9.18×10^{21} molecules of SF_4**

20. What is the **pH** of a 0.020 M solution of monochloroacetic acid ($CH_2ClCOOH$) ?
Data: $K_a (CH_2ClCOOH) = 1.35 \times 10^{-3}$

A) 2.08
B) 1.49
C) 2.34
D) 3.56
E) 4.21

Let $HA = CH_2ClCOOH$

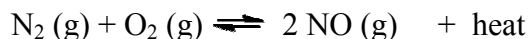|	HA $+ H_2O$	$\rightleftharpoons$	H_3O^+ (aq) $+$	A^- (aq)
I	0.020		0	0
C	-x		x	x
E	0.020-x		x	x

$$1.35 \times 10^{-3} = \frac{x^2}{(0.020 - x)}$$ ➔ $x^2 + 1.35 \times 10^{-3} x - 2.70 \times 10^{-5} = 0$ **SOLVE QUADRATIC**

$x = 4.56 \times 10^{-3} = [H_3O^+]$ ➔ **pH $= -\log(4.56 \times 10^{-3}) = 2.34$**

Note that the small x approximation CANNOT be used in this case.

21. The following reaction is carried out in a closed vessel.

$$N_2 \text{ (g)} + O_2 \text{ (g)} \rightleftharpoons 2 \text{ NO (g)} \quad + \text{ heat}$$

Which of the following conditions will **increase** the amount of NO at equilibrium ?

i. The reaction temperature is increased.
ii. The volume of the reaction container is reduced.
iii. He (g) is added to the reaction.
iv. The reaction temperature is lowered.
v. The partial pressure of O_2 is increased.

A)   i, iii
B)   ii, iv
C)   ii, iv
D)   i, v
E)   iv, v

(i) As T increases reaction proceeds in endothermic direction ➔ amount of NO decreases
(ii) As V increases reaction shifts to side with more gas species ➔ amount of NO decreases
(iii) If He is added (at constant volume) partial P do not change so the position if equilibrium will not change. If yhe V is allowed to increase, then (ii) is operational.
(iv) As T decreases reaction proceeds in exothermic direction ➔ amount of NO increases
(v) If partial pressure of O_2 increases, the raction shifts to consume some of the added O_2
   ➔ amount of NO increases

22. What is the **pH** of a 0.105 M aqueous solution of KOH?

A)   0.895
B)   13.021
C)   12.031
D)   11.439
E)   1.263

pOH = -log(0.105) = 0.979

pH = pK_w- pOH = 14.0 = 0.979 = **13.021**

Note 13.021 has only 3 significant figures (the power (13) does not contribute to the SF count)

23. A sealed container with a total volume of 2.0 L at 298 K is exactly half-filled with an ocean water standard that has a pH of 7.00 and contains no dissolved CO_2. The remaining volume is filled with air at a total pressure of 1.03 bar that is 0.040 mol % CO_2 (i.e. 0.040 % partial pressure of CO_2). The container is left overnight to equilibrate. In the morning, the pH of the ocean water is measured and found to be 5.98. Assuming that acidification of the ocean water only took place via the reaction below, what **percentage of CO_2** from the air sample has reacted to form HCO_3^- (aq) ?

$$CO_2 \text{ (aq)} + 2\,H_2O \text{ (l)} \rightleftharpoons H_3O^+ \text{ (aq)} + HCO_3^- \text{ (aq)} \qquad K_a(H_2CO_3) = 4.4 \times 10^{-7}$$

A) 21
B) 31
C) 53
D) 72
E) 15

$[H_3O^+] = 10^{-5.98} = 1.05 \times 10^{-6}$ M

$$CO_2 \text{ (aq)} + 2\,H_2O \text{ (l)} \rightleftharpoons H_3O^+ \text{ (aq)} + HCO_3^- \text{ (aq)}$$
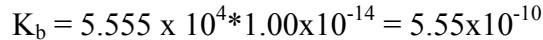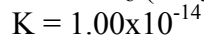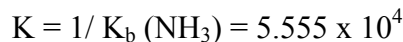
I	Y	0	0
C	-x	x	x
E	Y-x	x	x

$$K_a = \frac{[H^+][HCO_3^0]}{[CO_2]} = \frac{x^2}{Y-x} \qquad \text{or } Y = \frac{x^2}{K_a} + x = \frac{(1.05 \times 10^{-6})^2}{4.4 \times 10^{-7}} + 1.05 \times 10^{-6} = 3.56 \times 10^{-6}\,M$$

before equilibration there was 6.614×10^{-6} mol CO_2 (aq) in the 1.0 L of ocean water

initial # moles of CO_2 (g) $\quad n_i = \dfrac{P_i V}{RT} = \dfrac{(4 \times 10^{-4})(1.03 bar)(1.0L)}{(0.083145 bar.L.K^{-1}mol^{-1})(298.K)} = 1.663 \times 10^{-5}\,mol$

% of CO_2 reacted to form $HCO_3^- = 100*(3.56 \times 10^{-6})/\ 1.663 \times 10^{-5} = 21.4$ % or **21%** to S.F.

24. What is the **pH** of a solution prepared by dissolving 2.14 g NH_4Cl (MM = 53.491 g/mol) in 2.00 L water ? Assume that the addition of NH_4Cl does not affect the volume of the solution.   Data: $K_b(NH_3) = 1.8 \times 10^{-5}$

A) 7.47
B) 8.01
C) 3.41
D) 5.48
E) 6.02

NH_4^+ + OH^-	$\rightleftharpoons$	NH_3 + H_2O		$K = 1/K_b(NH_3) = 5.555 \times 10^4$
$2H_2O$	$\rightleftharpoons$	H_3O^+ (aq) + OH^-		$K = 1.00 \times 10^{-14}$
NH_4^+ (aq) + H_2O	$\rightleftharpoons$	NH_3 (aq) + H_3O^+(aq)		$K_b = 5.555 \times 10^4 * 1.00 \times 10^{-14} = 5.55 \times 10^{-10}$

I	2.14g/(2.00L*53.491g.mol^{-1})	0	0
C	-x	x	x
E	2.00×10^{-2} -x	x	x

$$K_b = \frac{[NH_3][H_3O^+]}{[NH_4^+]} = \frac{x^2}{0.020 - x} \approx \frac{x^2}{0.020} \quad \rightarrow \quad x = 3.33 \times 10^{-6}\,M = [H_3O^+] \quad \rightarrow \quad \textbf{pH = 5.48}$$

25. Which of the following statements are **FALSE** ?

    i)   The Arrhenius definition applies only to protic acids and metal hydroxides in water.
    ii)   The strength of a base can also be described by the stability of its conjugate acid.
    iii) For binary acids, the anion/conjugate base stability decreases down a group.
    iv) HF is a stronger acid than $HClO_4$.
    v)   HCl is defined as an acid in both the Lewis and Arrhenius descriptions of acid/base theory.

    A) iii, iv
    B) ii, iv
    C) i, iii
    D) ii, v
    E) i, v

(i) TRUE
(ii) TRUE - the more stable the conjugate acid, the stronger the base
(iii) FALSE - the acid strength INCREASES down group 17, which means the conjugate base stability INCREASES
(iv) FALSE $HClO_4$ is a strong acid; HF is a weak acid
(v) TRUE   All Arrhenius acids are also Bronsten-Lowry and Lewis acids. (converse not true)

26. Which of the following relationships are **FALSE** with respect to acid strength ?

    i)   HI < HCl
    ii) $HClO_3 < HClO_4$
    iii) $H_2O < NH_3$
    iv) HF < HBr
    v) $CBr_3COOH < CCl_3COOH$

    A) i, iii
    B) i, v
    C) ii, iii
    D) iv, v
    E) ii, iv

(i) FALSE - HI is a stronger acid than HCl
(ii) TRUE - $HClO_4$ is a strong acid , $HClO_3$ is a weak acid
(iii) FALSE - NH_3 is a base while water is amphoteric (acts as both acid & base)
(iv) TRUE – HBr is a strong acid , HF is a weak acid
(v) TRUE CBr_3 is less electronegative than CCl_3 so carboxylate is less stabilized

27. A 0.153 M solution of an acid, HA, has a percent ionization of 0.912 %. What is the value of the **acid dissociation constant**, K_a, for this acid ?

    A) 1.28×10^{-5}
    B) 1.87×10^{-5}
    C) 1.94×10^{-7}
    D) 1.59×10^{-6}
    E) 1.31×10^{-4}

	HA $\rightleftharpoons$	H^+	+	A^-
I	0.153	0		0
C	-x	x		x
E	0.153 - x	x		x

and $x = 9.12 \times 10^{-3} * 0.153 \text{ M} = 1.395 \times 10^{-3} \text{ M}$
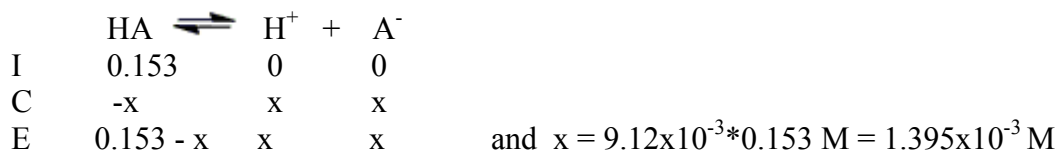
$$K_a = \frac{\left(1.395 \times 10^{-3}\right)^2}{0.153} = 1.277 x 10^{-5} = \mathbf{1.28x10^{-5}} \text{ to S.F.}$$

28. In experiment 2, The Cycles of Copper, a student records an initial mass of copper of 0.2512 g. The student has to leave lab early so the TA tells them to record the mass of the black precipitate rather than completing the remaining reactions that would return the copper to its elemental form. The student records the mass of the dried black precipitate as 0.2147 g. What **percent recovery** of copper did this student achieve ?

    A) 88.12
    B) 83.47
    C) 72.31
    D) 68.28
    E) 66.21

Black precipitate is CuO (*have to have done the lab to know this*)

MW (CuO) = 63.546 + 15.999 = 79.545 g/mol

Mass of 2.147g is (2.147g / 79.545 g/mol) = 2.699×10^{-3} mol

Original # moles of Cu = 0.2512 g/63.546 g/mol = 3.953×10^{-3} mol

% recovery (as CuO) = 100* 2.699×10^{-3} / 3.953×10^{-3} = 68.277 % = **68.28 %**   to S.F.

Extra space for rough work

Extra space for rough work

Some general data are provided on this page.

A Periodic Table with atomic weights is provided on the next page.

STP = 273.15 K, 1 atm

$N_A = 6.022 \times 10^{23}$ mol^{-1}

$h = 6.6256 \times 10^{-34}$ Js

density(H$_2$O, l) = 1.00 g/mL

Specific heat of water = 4.184 J / g·°C

$R = 8.3145$ J K^{-1} mol^{-1} = 0.08206 L atm K^{-1} mol^{-1} = 0.083145 L bar K^{-1} mol^{-1}

$F = $ 96485 C/mol

$c = 2.9979 \times 10^8$ m/s

$m_e = 9.109 \times 10^{-31}$ kg

$\Delta H^{\circ}_{vap}[H_2O] = 44.0$ kJ mol^{-1}

1 bar = 100.00 kPa = 750.06 mm Hg = 0.98692 atm

1 J = 1 kg m^2 s^{-2} = 1 kPa L = 1 Pa m^3

1 cm^3 = 1 mL

1 Hz = 1 cycle/s

0°C = 273.15 K

1 m = 10^6 µm = 10^9 nm = 10^{10} Å

1 g = 10^3 mg

De Broglie wavelength:

$\lambda = h / mu = h / p$

Hydrogen atom energy levels:

$E_n = -R_H / n^2 = -2.179 \times 10^{-18}$ J / n^2

$KE = \frac{1}{2}mu^2$

Nernst Equation:

$$E = E^{\circ} - \frac{RT}{zF}\ln Q \quad = E^{\circ} - \frac{0.0257\ V}{z}\ln Q \quad = E^{\circ} - \frac{0.0592\ V}{z}\log_{10} Q$$

Entropy change: $\Delta S = \dfrac{q_{rev}}{T}$

Aqueous Solubiity: Guidelines for Common Ionic Solids

Follow the lower-numbered guideline when two guidelines are in conflict. This leads to the correct prediction in most cases.

1. Salts of group 1 cations and the NH_4^+ cation are soluble . Except LiF and Li$_2$CO$_3$ which are insoluble.
2. Nitrates, acetates, bicarbonates, and perchlorates are soluble.
3. Salts of silver, lead and mercury (I) are insoluble. Except AgF which is soluble.
4. Fluorides, chlorides, bromides, and iodides are soluble. Except Group 2 fluorides which are insoluble
5. Carbonates, phosphates, chromates, sulfides, oxides, and hydroxides are insoluble. Except Group 2 sulfides and hydroxides of Ca^{2+}, Sr^{2+}, and Ba^{2+} which are soluble.).
6. Sulfates are soluble except for those of calcium, strontium, and barium.

PERIODIC TABLE OF THE ELEMENTS

Atomic weights are based on $^{12}C = 12$ and conform to the 1987 IUPAC report values rounded to 5 significant digits. Numbers in [ ] indicate the most stable isotope.