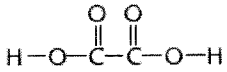
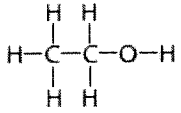
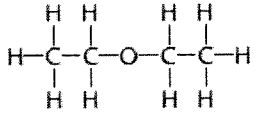
Day 10: Continue

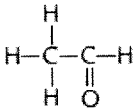
Questions 46 through 50 refer to types of organic compound below.

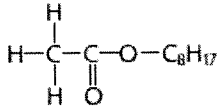
(A) alcohol
(B) aldehyde
(C) carboxylic acid
(D) ester
(E) ether

46. 

47. 

48. 

49. 

50. 

Day 10

STOP. Correct your answers and note how many correct **points**

Day 10: Answers and Explanations

Answer: Quick Check

1. **A**	2. **A**	3. **B**	4. **A**	5. **C**	6. **C**	7. **C**	8. **A**	9. **E**	10. **D**
11. **A**	12. **A**	13. **E**	14. **A**	15. D	16. **C**	17.B	18.**B**	19. **A**	20. **E**
21. **B**	22. **B**	23. **B**	24. **A**	25. **E**	26. **A**	27. **C**	28. E	29. **B**	30. **C**
31. **B**	32. **E**	33. **E**	34. **C**	35. **B**	36. **C**	37. **B**	38. D	39. **D**	40. **D**
41. **C**	42. **D**	43. **B**	44. D	45. **B**	46. **C**	47. **A**	48. **E**	49. **B**	50. **D**

Answers and Explanations

Questions 1 through 5: Le Chatelier's Principle, equilibrium reactions

1. **A** *Note:* N_2O in the equation is a reactant.
Note: To reestablish equilibrium from adding more reactant, the added reactant must be consumed.
Relate: Speeding up in the forward direction (***shift to the right***) allow the reaction to consume the added reactant.

2. **A** *Note:* O_2 in the equation is a product
Note: To reestablish equilibrium from removal of a product, the reaction will make more of that product.
Relate: Speeding up in the forward direction (***shift to the right***) allows the reaction to produce more of the removed product.

3. **B** *Note:* A decrease in volume means pressure is increased on the reaction.
Recall: To reestablish equilibrium from a pressure increase, more of the substances on the side that has fewer total moles must be produced.
Note: In the equation, the reactant side has fewer total moles (2)
Relate: A decrease in volume speeds up the reverse reaction (***shift to the left***) in order to produce more N_2O

4. **A** *Note:* The reaction has + ΔH value. This means :
Forward reaction is endothermic. Heat is absorbed as a reactant.
Reverse reaction is exothermic. Heat is released as a product
N_2O_2 + 163 KJ < ======= > $2N_2 + O_2$

Recall: To reestablish equilibrium from increased temperature, endothermic (forward) reaction is favored (***Shift to the right***) so the added heat can be consumed.

5. **C** *Recall:* Addition of a catalyst lowers the activation energies for both the forward and reverse reactions. As a result, both the forward and reverse reactions are increased equally, and there is ***no shift in either direction.***.

Questions 6 through 8: Electron configuration, atomic structure

6. **C** *Recall:* The electron configuration of a paramagnetic element must have a sublevel with at least one unpaired e-

Note: The configuration $1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^4$

↑↓ ↑↓ ↑↓ ↑↓ ↑↓ ↑↓ ↑↓ ↑ ↑

has **two unpaired** electrons in the 3p sublevel.

7. **D** *Note:* Both potassium ion (K+) and chlorine ion (Cl-) have 18 e- . Both have the same configuration $1s^2 2s^2 2p^6 3s^2 3p^6$, which is the same as that of the noble gas element closest to them (Ar)

8. **A** *Note:* The atom of this element (Ne) has only 2 electron shells. All of the others have 3 or more shells.

9. **E** **Solution – Beer's Law relationship**

Recall: According to Beer's law, absorbency is directly proportional to the concentration of a solution.

Note: To measure absorbance, a spectrometer is needed. An appropriate reagent must be a colored solution

Determine: $Ni(NO_3)_2$, which contains a transition metal, is the only colored solution listed.

10. **D** **Solubility Guideline, precipitate**

Note: A Precipitate is formed when an insoluble compound is formed from mixing two solutions.

Note: Mixing NaCl with $Pb(NO_3)_2$ produces **$PbCl_2$**(s).

Recall solubility guidelines: Chloride ion is mostly soluble, EXCEPT when it combines with **Pb^{2+}**, Ag^+, or Hg^{2+}

Day 10: Answers and Explanations

11. **A** **Boiling point–concentration relationship, van't Hoff factor**

Recall: The degree of boiling point elevation is related to the number of moles of ions in the solution. Solution with the greatest number of moles of ions will have the highest boiling point.

Note: Based on information given, the number of moles of ions in each solution can be calculated using the equation:

Moles of ion = Molarity x Volume x i (van't Hoff factor)

(A)	**Moles in KNO_3**	**=**	**0.50**	**x**	**.250**	**x**	**2 ions**	**= .250 moles**
(B)	Moles in $Al(NO_3)_3$ =		0.10	x	.400	x	4 ions	= .160 moles
(C)	Moles in NH_4NO_3 =		0.20	x	.500	x	2 ions	= .200 moles
(D)	Moles $AgNO_3$	=	0.30	x	.300	x	2 ions	= .180 moles
(E)	Moles in $Ni(NO_3)_2$ =		0.10	x	.200	x	3 ions	= .060 moles

Note: Choice A solution has the highest total moles of ions, therefore, highest boiling point

12. **A** **Ion concentration in solution**

Note: Highest NO_3^- concentration can be calculated for each solution using the equation:

$[NO_3^-]$ = M x moles of NO_3^- ions

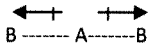
(A)	**$[NO_3^-]$ in KNO_3**	**=**	**0.50**	**x**	**1**	**=**	**. 50 M**
(B)	$[NO_3^-]$ in $Al(NO_3)_3$	=	0.10	x	3	=	. 30 M
(C)	$[NO_3^-]$ in NH_4NO_3	=	0.20	x	1	=	. 20 M
(D)	$[NO_3^-]$ in $AgNO_3$	=	0.30	x	1	=	. 30 M
(E)	$[NO_3^-]$ in $Ni(NO_3)_2$	=	0.10	x	2	=	. 20 M

Note: Choice A has highest $[NO_3^-]$

13. **E** **Factors affecting molecular shape**

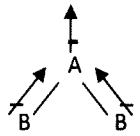
Note: Shape of AB_2 molecule can be determined if dipole moments of the molecule are known.

If dipole moments cancel out:



The molecule is linear and nonpolar

If dipole moments add (net dipole)



The molecule is bent and polar

Note: Non of the other properties (alone) will be enough to determine the shape of the molecule

14. **A** **Nuclear decay, emission particles**

Note: The difference between $^{19}_{8}O$ and $^{19}_{9}F$ is $^{0}_{-1}e$ (beta)

Note: Since this is a decay, the answer is beta emission, NOT, electron capture

15. **D** **Interpreting potential energy diagram**

Note: To determine the incorrect statement, consider each choice and eliminate those that are true of the energy diagram.

Note: **Eliminate Choice A.** True b/c product energy is higher than reactant's

Eliminate Choice B. True b/c Points 1 and 3 represent intermediates

Eliminate Choice C . True b/c the transitional point is measured at the activated complex

Eliminate Choice E. True b/c increasing energy at point 2 will result in a longer reaction pathway, hence, slower rate.

Note: **Choice D is false:** Equilibrium concentration of products depends on the initial concentration of reactants and final concentration of products only.
Therefore, raising energy of intermediate 3 will not affect the equilibrium concentration of the product

16. **C** **Energy change and pressure calculation, thermodynamic**

Recall : Recognize that based on information given, change in energy, ΔE , can be calculated using the First Law of thermodynamics equation below.

$\Delta E = q + w$ *Note:* $w = -(P_{ext} \times \Delta V)$

Rewrite equation, substitute factors into equation, and solve

$\Delta E = q - (P_{ext} \times \Delta V)\ 101.32\ J.L^{-1}.atm^{-1}$

$\Delta E = 505.64\ J - (2.0\ atm \times 1\ L)\ 101.32\ J.L^{-1}.atm^{-1}$

$\Delta E = 505.64\ J - 202.64\ J =$ **303.00 J**

17. **C** **Interpreting reaction equation**

Note: In the reaction, NH_4+ has 1 more H+ (proton) than NH_3

Recall: A species in a reaction with one more H^+ than another is the conjugate acid

Note: Non of the other choices is true or can be infer about the reaction based on just the equation given

18. **B** **Molecular shapes-hybridization relationship**

Recall the relationship between electron pairs, electron geometry and hybridization:

Electron pairs	*electron geometry*	*hybridization*
2	*linear*	*sp*
3	**trigonal planer**	$\boldsymbol{sp^2}$
4	tetrahedral	sp^3
5	trigonal bipyramidal	sp^3d
6	octahedral	sp^3d^2

19. **A** **Interpreting Gibb's free energy**

Recall: Free energy $\Delta G = \Delta H - T\Delta S$

Note: Since ΔH is + and ΔS is - as stated in the question, $\Delta G = +\Delta H + T\Delta S = +\Delta G$ (nonspontaneous) regardless of temperature (T)

20. **E** **Common-ion effect, solubility**

Note: Silver hydroxide (AgOH) is a base.

Relate: Its solubility will be hindered the most when placed in a solution with the highest OH- concentration (highest pH)

21. **B** **Quantum numbers interpretation**

Note: The set of numbers listed in the choices represents n, l, m_l, *and* m_s, respectively

Recall what each quantum number represents:

n	= shells	n value range:	1	to	7
l	= subshells	l value range:	0	to	$(n-1)$
m_l	= orbitals	m_l value range:	$-l$	to	$+l$
m_s	= spin	m_s values:	$-1/2$	or	$+1/2$

Note: Based on information above, m_l value should never be greater than l

Note: In Choice B, the m_l value (1) is greater than the l value (0). Therefore, B has the impossible set of quantum numbers.

22. **B** **Percent yield calculation, equation writing**

Step 1: Write a balanced equation for the reaction described.

$$4CH_4 + F_2 \text{ --------> } 2CH_3CH_2F + 3H_2$$

Step 2: Determine theoretical yield of 1-fluoroethane from 96-g CH_4.

$$96\text{ g } CH_4 \times \frac{1\text{ mol } CH_4}{16\text{ g } CH_4} \times \frac{2\text{ mol } CH_3CH_2F}{4\text{ mol } CH_4} \times \frac{48\text{ g } CH_3CH_2F}{1\text{ mol } CH_3CH_2F} = 144\text{ g } CH_3CH_2F$$

Step 3: Calculate percent yield

$$\%\text{ yield} = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100$$

$$\%\text{ yield} = \frac{96}{144} = \frac{2}{3} \times 100 = \mathbf{66\%}$$

Day 10: Answers and Explanations

23. **B** **Total pressure–mole fraction relationship**

Recognize that based on information given, total pressure (P_{total}) can be calculated using mole fraction equation

$$P_{total} = X_A P_A + X_B P_B \qquad X = \text{mole fraction}, \; P = \text{partial pressure}$$

Rewrite equation, substitute factors from question, and solve.

$$P_{total} = \left(\frac{\text{mole of A}}{\text{total moles}}\right) P_A + \left(\frac{\text{mole of B}}{\text{total moles}}\right) P_B$$

$$P_{total} = \left(\frac{1.50}{7.0}\right) 75\text{ mm Hg} + \left(\frac{5.50}{7.0}\right) 25\text{ mm Hg}$$

P_{total} = **35.7 mm Hg**

24. **A** **Solution properties**

Note: When solute particles (in this question, potassium and chloride ions) are present in water, they interact and interfere with certain physical and chemical properties of water.

Recall: The present of solute in water allows the solution to have: **Higher boiling point, lower freezing point, and lower vapor pressure**

25. E **Percent composition**

Step 1: Write the correct formula for calcium hydroxide: $Ca(OH)_2$

Step 2: Determine molar mass of $Ca(OH)_2$

Molar mass = 1 Ca + 2 O + 2H

Molar mass = 1(40) + 2(16) + 2(1) = 74 g/mol $Ca(OH)_2$

Step 3: Determine mass of Oxygen in 148 g $Ca(OH)_2$

$$\text{Mass of O} = 148\text{ g } Ca(OH)_2 \times \frac{32\text{ g O}}{74\text{ g } Ca(OH)_2} = \mathbf{64\text{ g O}}$$

26. A **Equilibrium expression**

Recall: $k_{eq} = \frac{[\text{Products}]}{[\text{Reactants}]} = \frac{[CO_2]^2}{[CO]^2}$

Note: Solids are not included in the equilibrium expression because they have constant concentrations

The exponents are the coefficients of the substances in the balanced equation.

27. C **Understanding Titration process**

Note: **Choice C** is the only correct statement. This statement will be true for all acid-base titration graphs.

Note: **Choice A** is false because the equivalent point of weak acid – strong base titration occurs at pH above 7.

Choice B is false because pH does not depends on indicator

Choice D is false because a basic salt will be produced, resulting in a sharp increase in pH

Choice E is false because [H+] is equal to the ionization constant, K_a, at the half-equivalence point; NOT at the equivalence point.

28. E **Phase change – Energy – Entropy – Free energy relationship**

Note the followings about the phase change of water given.

$H_2O(g)$ --------> $H_2O(l)$

Gas to liquid = **Exothermic** (heat is released) **ΔH = -**

Gas to liquid = **Entropy decreases** (less disorder) **ΔS = -**

Gas to liquid = **Spontaneously** (occurs by itself at room temp) **ΔG = -**

Day 10: Answers and Explanations

29. B **Half-reaction interpretation**

Note the followings about the half-reaction equation:

$AuCl_4^- + 3e^- \text{--------} > Au + 4Cl^-$

It represents reduction as written (e- is a reactant).

Gold changes from +3 to 0 (a reduction of oxidation state)

Recall: Reduction occurs at cathode **Choice B**

Note: Chloride ion does not change its oxidation state. (Eliminate D & E)

30. C **Coulombs law, factor-labeling**

Recognize that based on information given, grams of gold produced can be calculated by setting up factor-labeling. When all units are crossed out, what's left is the correct setup.

$$\frac{4.0\ C}{s} \times \frac{30\ min}{1} \times \frac{60\ s}{1\ min} \times \frac{1\ mol\ e^-}{96{,}500\ C} \times \frac{1\ mol\ Au}{3\ mol\ e^-} \times \frac{197\ g\ Au}{1\ mol\ Au}$$

$$\frac{\cancel{4.0\ C}}{\cancel{s}} \times \frac{\cancel{30\ min}}{\cancel{1}} \times \frac{\cancel{60\ s}}{\cancel{1\ min}} \times \frac{\cancel{1\ mol\ e^-}}{96{,}500\ \cancel{C}} \times \frac{\cancel{1\ mol\ Au}}{\cancel{3\ mol\ e^-}} \times \frac{197\ g\ Au}{\cancel{1\ mol\ Au}}$$

31. C **Atomic radius – nuclear charge relationship, ionic size comparison**

Recall: The size (radius) of atoms depends on factors such as:
Number of electron shells
Number of electrons
Number of protons (nuclear charge)

Note: All of the ions listed are isoelectronic, meaning they have the same number of electrons (10), therefore, same number of electron shells.

Relate: The difference in size of these ions depends mostly on their nuclear charges. The greater the nuclear charge, the smaller the radius. Therefore:

Order of increasing size = Order of decreasing nuclear charge

Smallest radius : Mg^{2+} (+12 nuclear charge)
F^- (+9 nuclear charge)
Largest radius : O^{2-} (+8 nuclear charge)

Day 10: Answers and Explanations

32. **E** **Completing equation, Solubility rules, precipitate**

Recall: Precipitate is formed when an insoluble compound is formed from mixing two solutions.

Determine product for each reaction, then use solubility rules to determine which product is insoluble

(I) $HBr + Ca(OH)_2 \text{ -----> } H_2O + CaBr_2$ *(soluble)*

(II) $Pb(NO_3)_2 + LiI \text{ ------> } LiNO_3$ *(soluble)* $+ PbI_2$ *(insoluble)*

(III) $(NH_4)_3PO_4 + MgCl_2 \text{ ----> } NH_4Cl$ *(soluble)* $+ Mg_3(PO_4)_2$ *(insoluble)*

Note: Both II and III produce insoluble (precipitate) products

33. **E** **Le Chatelier's Principle**

Note: All five reactions involve gaseous reactants and products.

Recall: Equilibrium concentration of substances in a gaseous reaction WILL NOT change when the total moles of reactants and products are equal.

Note: Reaction for Choice E is the only one listed with total moles of reactants and products being equal (3 moles on each side).

34. **C** **Equation writing, mass – mole calculation in equation**

Step 1: Write a correct balanced equation for the reaction described.

$4Al + 3O_2 \text{ -------> } 2Al_2O_3$

Step 2: Use factor- labeling to solve by utilizing mole ratio in equation

$$\text{mole of } O_2 = 25.5 \text{ g } Al_2O_3 \times \frac{1 \text{ mol } Al_2O_3}{102 \text{ g } Al_2O_3} \times \frac{3 \text{ mol } O_2}{2 \text{ mol } Al_2O_3}$$

mole of O_2 = **0.375 mol**

Day 10: Answers and Explanations

35. **B** **Oxidation of acids, acid formulas, acid strength**

Note: When an oxyacid (acid with oxygen) is oxidized, the number of oxygen of the acid increases. The new acid formed is stronger.

Note: When an oxyacid has the maximum number of oxygen that it could have, that acid can't be oxidized any further.
Ex: H_2SO_3 can be oxidized to form H_2SO_4
But
H_2SO_4 can't be oxidized any further.

Note: Of all the acids listed, only HNO_2 (a weaker acid) can be oxidized further (to HNO_3, a stronger acid)

-36. **C** **Enthalpy change/Energy change in equations, thermodynamics**

Recognize that based on information given, the equation
$\Delta H = \Delta E + P\Delta V$ (law of thermodynamic)
must be considered in order to correctly determine the reaction in which ΔH and ΔE are nearly equal.

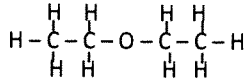
Note: Based on the equation, ΔH and ΔE will be equal only when $P\Delta V$ is equal to Zero. This will be the case if ΔV (change in volume) of the system is zero.

Relate: A reaction will have ΔV equal to zero if there are no gaseous substances involve in the reaction.

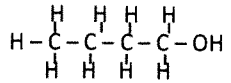
Note: Choice C is the only reaction of those listed in which there no gaseous substances are involved.

37. **B** **Comparing properties of organic compounds, isomers**

Recognize that one way to choose the correct statement about the boiling points of these two substances is to correctly draw and compare their structures and formulas.



$C_4H_{10}O$
diethyl ether



$C_4H_{10}O$
1-butanol

Note: Based on the structures and formulas, these two substances are isomers. (Eliminate Choice E)

Note: Based on the structures, diethyl ether is nonpolar (symmetrical) while 1- butanol is polar (asymmetrical).

Recall: Polar substances have higher boiling point than nonpolar.

Day 10: Answers and Explanations

38. **D** **Molar mass – rate relationship, comparing rate of gases**

Recall: Rate of effusion of gases is related to their molar masses (M) according to the equation below:

$$\frac{V_1}{V_2} = \sqrt{\frac{M_2}{M_1}}$$

Note: The mass of H_2 = 2 g

Relate: A gas that travels at $^1/_3$ the speed of H_2 must have a molar mass that is 9 times as great as the molar mass of H_2

Note: H_2O has a molar mass of 18 g (9 times as great as 2 g)

39. **C** **Bond angle-Molecular shape relationship**

Note that drawing the Lewis diagram for the nitrate ion is one way of determining its shape, as well as the N – O bond angle.

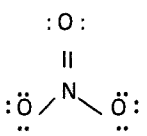
Determine number of electrons available for bonding in NO_3^-, and then draw the Lewis structure for NO_3-

N = 1(5) = 5 e-

O = 3 (6) = 18 e-

-1 = 1 e-

Total e- = 24 e-



Note: The shape of NO_3^- is trigonal planer. Bond angles of this shape is always 120°

40. **D** **Titration data interpretation, sources of errors**

Note: Only the NaOH volume for the first sample is, in terms of titration, significantly different from the rest.

Note: The only reasonable explanations is that the pipet that was used to transfer the acetic acid in the first sample was not rinsed with the acid.

Note: All other errors listed will not affect the volume of the titrant (NaOH)

Day 10: Answers and Explanations

41. **C** **Entropy Change calculation**

Step 1: Recall entropy change, ΔS°, equation

$$\Delta S^\circ = \Sigma^\circ S \text{ products} - \Sigma^\circ S \text{ reactants}$$

Step 2: Substitute numbers from table into equation. Be sure to take number of moles of substances in the balanced equation into account .

$$\underset{}{\mathbf{3}\,Mg + Al_2O_3} \qquad \underset{}{\mathbf{2}\,Al(s) + \mathbf{3}\,MgO}$$

$$\Delta S^\circ = \left[\mathbf{3}\,(33.0) + 51.0\right] - \left[\mathbf{2}\,(28.0) + \mathbf{3}\,(27.0)\right]$$

$$\Delta S^\circ = 150 - 137 = \mathbf{13.0\ J/(mole.K)}$$

42. **D** **Flame test**

Recall your flame test colors: Lithium always red

43. **B** **Percent abundance of isotopes, Atomic mass calculation**

Note: Since the atomic mass (63.55) is closer to the mass of ^{63}Cu, the percent of ^{63}Cu will be greater than that of ^{65}Cu

Eliminate choice C and D (these choices reflect greater % of ^{65}Cu)

Note: One way to quickly solve this problem is to set up the problem as follows:

Let x = decimal fraction of percent of ^{63}Cu

then 1 – x = decimal fraction of percent of ^{65}Cu

Recall: Atomic mass is the sum of the products of decimal fraction x mass number of the isotopes

$$63(x) + 65(1 - x) = 63.55$$

$$63x + 65 - 65x = 63.55$$

$$2x = 1.45$$

$$x = .73 \approx \mathbf{70\%\ of\ ^{63}Cu}$$

Day 10: Answers and Explanations

44. **D** **Equilibrium expression calculation, dissociation**

Recognize that K_a can be determined from equilibrium expression.

Step 1: Write equation for the dissociation of $HC_2H_3O_2(aq)$

$$HC_2H_3O_2\,(aq) \;<=====>\; H+\,(aq) \;+\; C_2H_3O_2\text{-}(aq)$$

Step 2: Write equilibrium expression for above equation

$$K_a = \frac{[H+]\,[C_2H_3O_2\text{-}]}{[HC_2H_3O_2]}$$

Step 3: Determine concentrations:

$[H+] = -\log pH = -\log(2) = .01$ M

$[C_2H_3O\text{-}] = [H+] = .01$ M (based on mole ratio of **1**H+ : **1**$C_2H_3O_2$-)

$[HC_2H_3O] = 1.0$ M (concentration of a weak acid like acetic stays nearly unchanged b/c weak acids dissociate very slightly)

Step 4: Substitute [ ] into equation and solve for Ka

$$K_a = \frac{(0.01)\;(0.01)}{1.0} = .0001 = \mathbf{1.0 \times 10^{-4}}$$

45. **B** **Percent calculation**

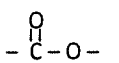
$$\%\text{ dissociation} = \frac{[\text{Part}]}{[\text{whole}]} \times 100$$

$$\%\text{ dissociation} = \frac{.01\text{ M}}{1.0\text{ M}} \times 100 = \mathbf{1.0\,\%}$$

Day 10: Answers and Explanations

Questions 46 through 50: Organic functional groups

Recall the functional group associated with each class of organic compound listed as choices

class	functional group
(A) alcohol	- OH
(B) aldehyde	
(C) carboxylic acid	
(D) ester	
(E) ether	– O –

46. **C** *Note:* Structure given contains a *carboxylic acid* functional group

47. **A** *Note:* Structure given contains an *alcohol* functional group

48. **E** *Note:* Structure given contains an *ether* functional group

49. **B** *Note:* Structure given contains an *aldehyde* functional group

50. **D** *Note:* Structure given contains an *ester* functional group

Day 11: Answers and Scoring Guidelines

(see important scoring guideline information on on pg i)

1. Hypochlorous acid, HOCl, is a weak acid that ionizes in water, as shown in the equation below

$$HOCl(aq) \quad <====> \quad H^+(aq) + OCl^-(aq)$$
$$K_a = 2.9 \times 10^{-8}$$

(a) Calculate the $[H^+]$ in a HOCl solution that has a pH of 5.24.

Recall: $pH = -\log [H^+]$

$[H^+] = 10^{-pH}$ $[H^+] = 10^{-5.24} = \mathbf{5.75 \times 10^{-6}}$	**1 point** is earned for correctly calculating the $[H^+]$

(b) Using information provided above:

(i) Write the equilibrium expression (K_a) for the ionization of HOCl in water.

Recall: $K_a = \dfrac{[\text{Products}]}{[\text{Reactants}]}$

$K_a = \dfrac{[H^+][OCl^-]}{[HOCl]}$	**1 point** is earned for the correct equilibrium expression

(ii) Calculate the concentration of HOCl(*aq*) in a HOCl solution that has $[H^+]$ equal to 2.4×10^{-5} M.

Note: $[OCl^-] = [H^+]$ because they are at 1 : 1 ratio in the equation.

$[HOCl] = \dfrac{[H^+][OCl^-]}{K_a}$ $[HOCl] = \dfrac{\mathbf{(2.4 \times 10^{-5}\ M)(2.4 \times 10^{-5})}}{\mathbf{2.9 \times 10^{-8}}}$ $[HOCl] = \mathbf{= 2.0 \times 10^{-2}\ M}$	**1 point** is earned for the correct setup to calculate [HOCl] **1 point** is earned for [HOCl] that is consistent with the setup

(c) A solution of $Ba(OH)_2$ is titrated into a solution of HOCl.

(i) Calculate the volume of 0.200 M $Ba(OH)_2(aq)$ needed to reach the equivalence point when titrated into a 75.0 mL sample of 0.150 M HOCl(aq).

Recall: (moles of OH-)(M_b) (V_b) = (moles of H+) (M_a) (V_a)

Note: $Ba(OH)_2$ contains 2 moles of OH-
HOCl contains 1 mole of H+

Substitute values from question into equation and solve for volume of $Ba(OH)_2$ (V_b) (moles of OH-)(M_b) (V_b) = (moles of H+) (M_a) (V_a) (2) (0.200 M) V_b = (1) (0.150 M) (0.075 L) **V_b = 0.0281 L $Ba(OH)_2$**	**1 point** is earned for the correct volume

(ii) Write the equilibrium expression, K_b, for the titration reaction that occurs.

Note: $OCl^- + H_2O$ ------ > $HOCl + OH^-$

$K_b = \dfrac{[HOCl]\,[OH^-]}{[OCl^-]}$	**1 point** is earned for the correct expression

(iii) Calculate k_b of OCl^-

Recall:

$K_w = K_b \times k_a$

$k_b = \dfrac{K_w}{K_a} = \dfrac{1.0 \times 10^{-14}}{2.9 \times 10^{-8}} = \mathbf{3.4 \times 10^{-7}}$	**1 point** is earned for the correct k_b

(iv) Calculate the pH at the equivalence point.

Note: Once [OH-] is known, pH can be calculated.

Note: [OH-] can be calculated by substituting values from the question and calculations (i – iii) into the k_b equation

Calculate [OCl-] $[OCl^-] = \dfrac{\text{moles of } OCl^-}{\text{Total volume}} = \dfrac{\text{Molarity} \times \text{Volume}}{(V_a + V_b)}$ $[OCl^-] = \dfrac{(0.150\ mol.L^{-1})\,(0.075\ L)}{(0.075\ L + 0.0281\ L)} = 0.109\ M$ *Determine concentrations* [OH-] = X [HOCl] = X because they at a 1 : 1 ratio *Substitute [ ] into k_b expression and solve for X)* $K_b = \dfrac{[HOCl]\,[OH^-]}{[OCl^-]}$ $3.4 \times 10^{-7} = \dfrac{X^2}{0.100}$ $1.93 \times 10^{-4} = X = [OH^-]$	**1 point** is earned for setup that leads to calculation of [OH-] or [H+]
Calculate pOH $pOH = -\log [OH^-] = -\log (1.93 \times 10^{-4}) = 3.72$ *Calculate pH* **pH = 14 - pOH = 14 - 3.71 = 10.28**	**1 point** is earned for correctly calculating the pH

(d) $HClO_3$ is a stronger acid than HOCl. Account for this fact in terms of molecular structure.

Note: In both HOCl and $HClO_3$, H – O bond must be broken for the acids to ionize.

The weaker the H – O bond, the easier it is for the acid to ionize, and the stronger the acid.

$HClO_3$ is a stronger acid than HOCl because the H – O bond in $HClO_3$ is weaker than the H – O bond in HOCl. This is due to the fact that the additional O atoms that are bonded to the central Cl atom in $HClO_3$ weakens its H – O bond.	**1 point** is earned for the correct explanation.

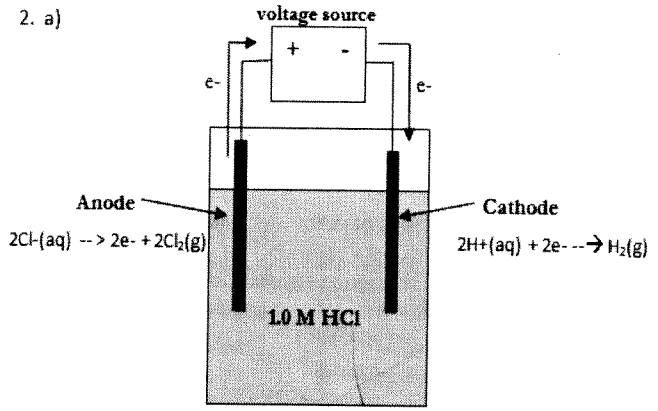
Day 11: Answers and Scoring Guidelines

2. Electrical current is passed through a 1.0*M* solution of HCl(*aq*) by means of two nonreactive electrodes immersed into the solution, with the electrodes connected to opposing terminals of a voltage source.

(8 points)

(a) (i) Sketch and label the diagram of the electrolytic cell, (ii) labels for anode and cathode, (iii) write half- reaction occurring at each electrode, and (iv) direction of electron flow.

2. a)



Your diagram will vary greatly from the one above. Points are based on the followings:

(i) A correctly sketched diagram must have: **one cell (beaker) , a voltage source, two bars connected to the positive and negative ends of the voltage source and submerged in HCl solution.**	**1 point** for a correct diagram
(ii) Metal bar connected to + is labeled **"Anode"** and Metal bar connected to – is labeled **"Cathode"**	**1 point** for correctly labeled anode and cathode
(iii) Half-reaction at + electrode: **$2Cl^-(aq) \rightarrow 2e^- + Cl_2(g)$** and Half-reaction at - electrode **$2H^+(aq) + 2e^- \rightarrow H_2(g)$**	**1 point** for correct and balanced half-reactions at + and - electrodes
(iv) **Direction of e-** is shown from bar at + to bar at –	**1 point** for correct direction of e-

(b) 4.5 amperes of current is applied to the reaction for 20 minutes.

(i) How many Coulombs pass through the cell during that time?

Note: 4.5 amp = 4.5 coulomb/sec (1 amp = 1 coulomb/sec)

20 minutes = 1.2×10^3 sec

Note: $I = \frac{q}{t}$ (see Reference Materials pg 340)

Charge (q) = time (t) x current (I) Charge (q) = 1.2×10^3 sec x $\frac{4.5 \text{ coulombs}}{\text{sec}}$ Charge (q) = **5.4×10^3 coulombs**	**1 point** is earned for the correct charge

(ii) How many moles of electrons pass through the cell during that time?

Note: 1 mole of e- = 96500 coulombs (Faraday's constant)

moles of e- = charge x Faraday's constant moles of e- = 5.4×10^3 coulombs x $\frac{1 \text{ mole e-}}{96500 \text{ coulombs}}$ moles of e- = **5.6×10^{-2} mol**	**1 point** is earned for correct moles of e-

iii) If the system is at STP, how much volume of hydrogen gas is produced during that time?

Recall: 1 mole of gas = 22.4 L at STP

Determine moles of H_2 using mole proportion in the half-reaction equation: **$2H^+ + 2e^- \text{ --------} > H_2$** 5.6×10^{-2} mol e- x $\frac{1 \text{ mole } H_2}{2 \text{ moles e-}}$ = **0.028 moles H_2**	**1 point** is earned for calculating moles of H_2
Calculate volume of H_2 Volume of H_2 = moles of H_2 x 22.4 L/mol Volume of H_2 = 0.028 mol x 22.4 L/mol = **0.627 L**	**1 point** is earned for correct volume of H_2

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(c) What happens to the pH of the HCl solution as current passes through it within the cell? Justify your response with explanation.

Recall: pH is related to H+ concentration of a solution.

Note: As current passes through the solution, H+ ion of the HCl solution is converted to H_2.
As a result, [H+] decreases.

pH increases	**1 point** is earned for indicating that **p**H increases
pH increases because **the H+ concentration decreases as the electrolytic processes is taking place.** A decrease in H+ resulted in an increase in phi	**1 point** is earned for explanation that is consistent with change in pH indicated.

Day 12: Answers and Scoring Guidelines

(see important scoring guideline information on on pg i)

1. **(15 points)**

(a) Dinitrogen oxide is mixed with water?

Recall: Nonmetal oxide combines with water to produce an acid.

Note: The acid (HNO_3) formed is left in an ionized form because nitric acid is a strong acid. Strong acids ionize completely.

(i) Balanced equation N_2O_5 + H_2O -------> $2H^+$ + $2NO_3^-$ *nonmetal oxide* *water* *acid*	**1 point** is earned for correct reactants **2 points are** earned for correct products **1 point** is earned for correctly balancing the equation

(ii) Would the pH of the solution that is produced less than 7, equal to 7, or greater than 7. Explain your answer.

The pH would be less than 7 because an acidic solution is formed.	**1 point** is earned for the correct pH with explanation

(b) Carbon dioxide gas is heated in the presence of solid magnesium oxide.

Note: This is a combination reaction in which a salt is formed from a basic and an acid anhydrides.

(i) Balanced equation CO_2 + MgO ------ > $MgCO_3$ *Basic anhydride* *Acid anhydride* *Salt*	**1 point** is earned for correct reactants **2 points are** earned for correct products **1 point** is earned for correctly balancing the equation

(ii) How many grams of magnesium oxide must completely react with 11 grams of the carbon dioxide?

Determine moles of CO_2 in 11 g. $11\ g\ CO_2 \times \frac{1\ mole\ CO_2}{44\ g\ CO_2} = 0.25\ mol\ CO_2$ *Determine moles of MgO based on proportion* $0.25\ mol\ CO_2 \times \frac{1\ mol\ MgO}{1\ mol\ CO_2} = 0.25\ mol\ MgO$ *Calculate grams of MgO* $0.25\ mol\ MgO \times \frac{40\ g\ MgO}{1\ mol\ MgO} =$ **10 g MgO**	**1 point** is earned for correctly calculating the grams of magnesium oxide

(c) Small pieces of aluminum are added to a solution of copper(II) sulfate.

Note: This is a single replacement redox reaction
Note: Sulfate ions is unchanged in the reaction. Therefore, it is not included in the equation.

(i) Balanced equation 2 Al + 3 Cu^{2+} -----> 2 Al^{3+} + 3 Cu	**1 point** is earned for correct reactants **2 points are** earned for correct products **1 point** is earned for correctly balancing the equation

(ii) Write the correct oxidation and reduction half equations for the reaction that occurs.

Oxidation-half: Al ------ > Al^{3+} + $3e^-$ *Reduction-half:* Cu^{2+} + $2e^-$ ----> Cu	**1 point** is earned for the correct oxidation and reduction half equations

2. Use your knowledge of redox and electrochemistry to answer the following questions. **(8 points)**

(a) What is the function of a salt bridge in a galvanic cell, and why is it necessary in order the cell work?

Recall: A salt bridge connects the two compartments of a galvanic cell

A salt bridge **allows anions (-) and cations (+) to flow** between the two compartments. A salt bridge is required for a galvanic cell to work because **the flow of the ions maintains cell neutrality .**	**1 point** is earned for correct function **1 point** is earned for correct explanation.

(b) Explain why, when a piece of nickel is placed in hydrochloric acid, a reaction occurs, but when a piece of copper wire is placed in hydrchloric acid, no reaction occurs.

Recall: Spontaneous redox reaction occurs when potential (E) is +.

A reaction occurs between the nickel (Ni) and HCl solution because the reaction has a positive potential (+E). According to the Table of Reduction Potentials: E_{oxi} Ni ----> Ni^{2+} + 2e- = + 0.25 V E_{red} 2 H+ + 2e- -----> H_2 = 0.00 V E for reaction = **+ 0.25 V**	**1 point** is earned for correctly explaining (or showing) why reaction occurs with Ni
A reaction did not occur between the copper wire (Cu) and the HCl solution because the reaction has a negative potential (-E). E_{oxi} Cu ----> Cu^{2+} + 2e- = - 0.34 V E_{red} 2 H+ + 2e- -----> H_2 = 0.00 V E for reaction = **- 0.34 V**	**1 point** is earned for correctly explaining (or showing) why no reaction occurs with Cu

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(c) Cu^{2+} + Pb(s) -----> Cu(s) + Pb^{2+}

(i) Give the standard cell potential for the reaction above.

Recall: $E_{cell} = E_{oxi} + E_{red}$

Note: Use Table of Reduction Potential on pg 338 to get E for each half-reaction. Be sure to reverse the sign for oxidation half.

E_{oxi} Pb ----> Pb^{2+} + 2e- = +0.13 V E_{red} Cu^{2+} + 2e- -----> Cu = + 0.34 V E_{cell} for reaction = **+0.47 V**	**1 point** is earned for the correct cell potential

(ii) What happens to the cell potential in (i) when $[Pb^{2+}]$ is increased? Explain.

The E_{cell} will decrease because $[Pb^{2+}]$ is a product, and increasing [ ] of a product forces the reaction to shift left (favors the reverse reaction). This decreases the voltage that is produced by the cell.	**1 point** is earned for the correct change in E_{cell} with explanation

(iii) What is the value of ΔG° for the cell?

Note: $\Delta G^\circ = -nFE$ (See Reference Materials on pg 339)

Note: n = moles of electrons = 2 (see equations in (i))
F = Faraday's constant = 96500 C/mol (see Reference materials)

$\Delta G^\circ = - nFE$ ΔG° = -(2) (96500 C/mol)(+0.47 V) ΔG° = **- 90710 C.V/mol** **- 90710 J/mol or 90.7 KJ/mol**	**1 point** is earned for correct setup **1 point** is earned for correctly calculating ΔG°