Chemistry 1A, Spring 2007

FINAL EXAM
May 14, 2007
(3 hours, closed book)

Name:__________________________

SID:____________________________

TA Name:________________________

1.) Write your name on every page of this exam.

2.) This exam has 80 multiple choice questions. Fill in the Scantron form AND circle your answer on the exam.

3.) There is no penalty for guessing, so answer every question.

4.) Some questions may require bubbling in more than one choice to receive credit.

Name_________________________

$E = h\nu$

$\lambda\nu = c$

$\lambda_{deBroglie} = h / p = h / mv$

E_{kin} (e-) $= h\nu - \Phi = h\nu - h\nu_0$

$$E_n = -\frac{Z^2}{n^2} R_\infty$$

$\Delta x \, \Delta p \sim h$

$p = mv$

Particle in a box (1-D Quantum):

$E_n = h^2 n^2/8mL^2$; $n = 1, 2, 3...$

$PV = nRT$

$$E_{kin} = \frac{3}{2} RT$$

$$v_{rms} = \sqrt{\frac{3RT}{M}}$$

$\Delta E = q + w$

$w = - P_{ext}\Delta V$

$$\Delta E = \frac{3}{2} nR\Delta T$$

$N_0 = 6.02214 \times 10^{23}$ mol^{-1}

$R_\infty = 2.179874 \times 10^{-18}$ J

$R_\infty = 3.28984 \times 10^{15}$ Hz

$k = 1.38066 \times 10^{-23}$ J K^{-1}

$h = 6.62608 \times 10^{-34}$ J s

$m_e = 9.101939 \times 10^{-31}$ kg

$c = 2.99792 \times 10^{8}$ m s^{-1}

Gas Constant:

$R = 8.31451$ J K^{-1} mol^{-1}

$R = 8.20578 \times 10^{-2}$ L atm K^{-1} mol^{-1}

T (K) = T (C) + 273.15

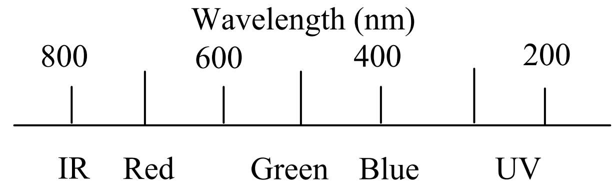
F = 96,485 C / mol

1 V = 1 J / C 1 nm = 10^{-9} m

1 kJ = 1000 J

Cp (water) = 4.184 J/g·^{o}C

Color and Wavelength of Light



$\Delta G° = \Delta H° - T\Delta S°$

$\Delta H° = \Sigma \, \Delta H°_f$ (products) $- \Sigma \, \Delta H°_f$ (reactants)

$\Delta S° = \Sigma \, S°$ (products) $- \Sigma \, S°$ (reactants)

$\Delta G° = \Sigma \, \Delta G°_f$ (products) $- \Sigma \, \Delta G°_f$ (reactants)

$S = k_B \ln W$

$\Delta G° = - RT\ln K$

$$\ln K = -\frac{\Delta H°}{R}\frac{1}{T} + \frac{\Delta S°}{R}$$

$\Delta G° = - nF\Delta Є^o$

$pX = - \log X$

$$pH = pK_a + \log\frac{[A^-]}{[HA]}$$

$$t_{1/2} = \frac{\ln 2}{k}$$

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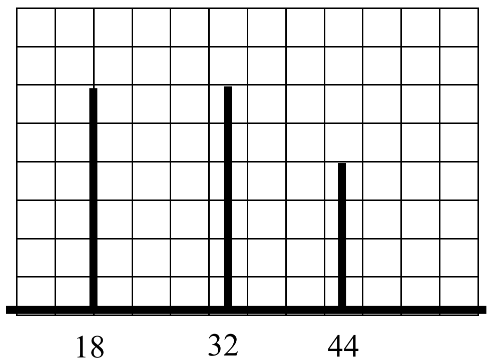
1.) What is the empirical formula of a hydrocarbon that is composed of 20% hydrogen and 80 % carbon by weight?

A) CH B) C_2H_6 C) CH_4 D) CH_3 E) C_2H_3

2.) A pure hydrocarbon sample was combusted in oxygen and the resultant mixture of gases analyzed using mass spectrometry. Which of the following statements about the data is false?



A) All of the hydrocarbon was consumed by the combustion.
B) Oxygen gas was in excess in the reaction.
C) The molar mass of the hydrocarbon is 32.
D) Water is a product of the reaction.
E) Carbon dioxide is a product of the reaction.

3.) What is the mass (in grams) of 2.5 L of gasoline if the density of gasoline is 0.79 g/ml?

A) 2.0 B) 1.98 C) $2.0 \cdot 10^3$ D) $1.98 \cdot 10^3$ E) $3.2 \cdot 10^3$

4.) What volume (in L) does the reaction mixture occupy after the reaction of 10 L of Cl atoms form Cl_2 at constant temperature and pressure?

A) 1 B) 5 C) 10 D) 15 E) 20

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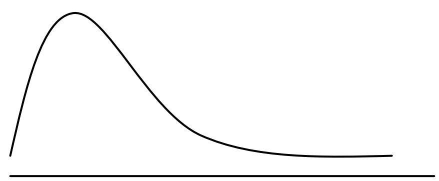
5.) What color does a normally blue object appear when viewed through a filter with the absorption profile shown here?



red orange yellow green blue violet

A) clear B) green C) blue D) black E) can't tell

6.) Light of 450 nm wavelength will eject electrons from a metal sample. Which also must be true?

A) Light of 500 nm will also eject electrons.
B) Light of 400 nm will also eject electrons.
C) 450 nm light of greater intensity will eject electrons with greater kinetic energy.
D) 600 nm light will eject electrons provided the intensity is great enough.
E) None are true.

7.) A blue advertising sign emits light with a wavelength of 465 nm. When the power is reduced, the light is dimmer. What has changed (mark all that apply)?

A) The wavelength of the light.
B) The frequency of the light.
C) The number of photons per second emitted.
D) The energy of the photons emitted.
E) All of these.

8.) Which particles can have a 'zero-point' kinetic energy of zero? Mark all that apply.

A) 450 nm photons.
B) Electrons traveling at around 10^5m/s.
C) Particles of sand (mass 0.01 g) in the wind traveling at around 30 m/s.
D) 170 g baseballs traveling at around 10 m/s.
E) None of the above

9.) Relative to an electronic energy level, which condition represents zero energy?

A) The electron and nucleus infinitely separated.
B) The ground state.
C) The nucleus.
D) n=0.
E) None of these.

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10.) How many unique spectral emission lines are observed from a system with four equally spaced energy levels?

A) 1 B) 2 C) 3 D) 4 E) 6

11.) How many electrons can share the quantum numbers n=3, ℓ=1?

A) 1 B) 2 C) 3 D) 4 E) 6

12.) Which set of quantum numbers is not possible?

A) $n = 2, \ell = 0, m_\ell = 0, m_s = ½$
B) $n = 2, \ell = 1, m_\ell = 0, m_s = ½$
C) $n = 3, \ell = 3, m_\ell = 1, m_s = ½$
D) $n = 4, \ell = 2, m_\ell = 1, m_s = ½$
E) $n = 5, \ell = 4, m_\ell = 2, m_s = ½$

13.) How much energy is released (in Rydbergs) when a He^{+1} ion relaxes from its 2p state to its 1s state?

A) 1 B) 2 C) 3 D) 4 E) 5

14.) An excited hydrogen atom emits light with a wavelength of 397.2 nm to reach the energy level for which n=2. In which principal quantum level did the electron begin?

A) 1 B) 3 C) 4 D) 6 E) 7

15.) What is the net energy change in making the NaCl molecule (kJ/mol) from the elements in their standard states?

A) -642 B) 0 C) 147 D) 323 E) 510

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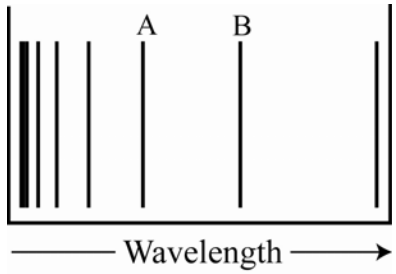
16.) The figure below represents part of the emission spectrum for a one-electron ion in the gas phase. The lines shown are the result of electronic transitions to the n=3 state. The wavelength of line B is 142.5 nm. What is the identity of the ion?



A) He^{+} B) He C) Li^{2+} D) Be^{3+} E) Be^{2+}

17.) Which of the following is isoelectronic with CO?

A) CO_2
B) O_2
C) Cl_2
D) F_2
E) N_2

18.) Which of the following molecules is polar? Mark all that apply.

A) SO_2F_2 B) SO_3 C) SF_4 D) SF_6 E) CH_4

19.) How many valid structural isomers exist for the molecular formula C_6H_{14}?

A) 1 B) 2 C) 3 D) 4 E) 5

20.) Which atomic orbital has the greatest number of angular nodes?

A) 1s B) 2s C) 3s D) 3p E) 4d

21.) The process of removing an electron from a neutral element in the gas phase...

A) requires energy for all elements, because the initial state is less stable than the final state.
B) requires energy for all elements, because the initial state is more stable than the final state.
C) does not require energy for any element, because the initial state is the same energy as the final state.
D) requires energy for some elements, because sometimes the initial state is more stable than the final state.

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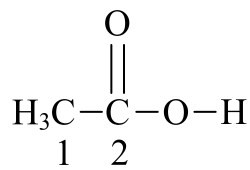
Consider the Lewis Structure for acetic acid (electron lone pairs not shown):



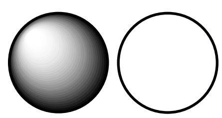
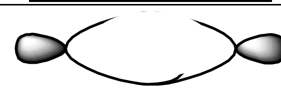
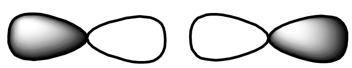
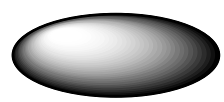
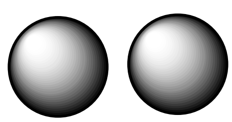
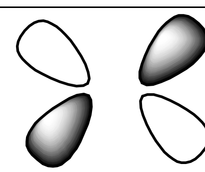
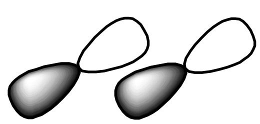
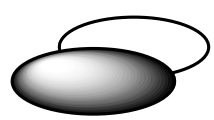
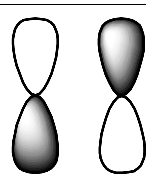
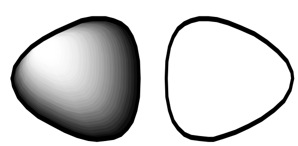
22.) What is the hybridization on carbon atom one (1) in acetic acid?

A) s B) sp C) sp^2 D) sp^3 E) sp^4

23.) What is the O-C-O bond angle in acetic acid?

A) 60 B) 90 C) 120 D) 180 E) 270

Match up each of the atomic orbitals shown with the molecular orbital formed by their linear combination.

Question	Atomic Orbitals			Molecular Orbitals
24.) E			A	
25.) A			B	
26.) B			C	
27.) D			D	
28.) C			E	

Name________________________

29.) Which flask(s) will have the greatest number of collisions per second with the walls of the container?

A) O_2 at 760 torr and 10^{o}C.
B) N_2 at 900 torr and 80^{o}C.
C) He at 800 torr and 10^{o}C.
D) He at 500 torr and 80^{o}C.

30.) Consider a system which releases 546 kJ of heat while its internal energy drops by 125 kJ. What can you infer about the process? Mark all that apply.

A) Work is involved.
B) The entropy of the system decreases.
C) It is spontaneous.
D) The first law of thermodynamics does not apply.

31.) A 10.00 gram sample of water absorbs 1000 J of heat. By how many Kelvin does its temperature change (assume no phase change)?

A) 10 B) 24 C) 36 D) 100 E) 1000

32.) Consider the following reactions carried out at a constant temperature and pressure. In which of these will the amount of work done be positive? Hint: only the coefficients of the reactants are given. All species are gas unless otherwise noted. Mark all that apply.

A) The synthesis reaction of 2 mol SO_2 and 1 mol O_2 to give SO_3.
B) The decomposition reaction of 4 mol NO to give O_2 and N_2.
C) The decomposition reaction of 2 mol CCl_2O to give CO and Cl_2.
D) The combustion of 2 mol CH_3OH.
E) The conversion of 2 mol of solid I_2 to gaseous I_2.

33.) We have seen many times in lecture that heat is given off in the combustion of hydrogen gas. Which of the following is responsible for the heat given off?

A) Breaking H-H and O-O bonds.
B) Breaking O-H bonds.
C) Forming H-H bonds and O-O bonds.
D) Forming O-H bonds.
E) Condensation of the water formed.

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34.) Given that the reaction below is endothermic, what is the effect of increasing the temperature at equilibrium? Mark all that apply.

$$N_2\,(g) + O_2\,(g) \leftrightarrow 2\,NO\,(g)$$

A) An decrease in the partial pressure of O_2.
B) A shift toward reactants.
C) A shift toward products.
D) A change in the equilibrium constant, K_{eq}.
E) None of these.

35.) The equilibrium position is quantified by the equilibrium constant, K. Which of the following generalized statements regarding K is *false*? Mark all that apply.

A) When K is larger than 1, the equilibrium position favors the formation of products.
B) When K is larger than 1, the value of ΔG^o for the reaction is always negative.
C) When K is equal to 1, the number of moles of reactants is always equal to the number of moles of product.
D) When K is larger than 1, the forward reaction is always occurring faster than the reverse reaction is.
E) When K is smaller than 1, the value of ΔH for the reaction is always negative.

36.) Which of the following is the *best* buffer system?

A) 0.0001 M acetic acid & 0.0001 M potassium acetate
B) 0.100 M acetic acid & 0.100 M potassium acetate
C) 0.010 M nitric acid & 0.010 M sodium nitrate
D) 0.100 M nitric acid & 0.100 M potassium acetate
E) 0.100 M acetic acid & 0.100 M ammonia

37.) What is the pH of 0.1 M HCl solution?

A) 0.0 B) 1.0 C) 2.0 D) 5.0 E) 7.0

38.) Carbonate buffers are important in regulating the pH of blood to keep it at 7.40. What is the ratio of the concentration of carbonic acid to bicarbonate ions in blood at a pH of 7.40?

$$H_2CO_3(aq) \leftrightarrow HCO_3^-(aq) + H^+(aq) \qquad K_a=4.3\cdot10^{-7}$$

A) 11 B) 1.0 C) 0.90 D) 14 E) 0.073

39.) The indicator methyl red has a Ka = $5.0 \cdot 10^{-6}$. For which pH range will methyl red be an appropriate indicator?

A) 1-3 B) 2-4 C) 3-5 D) 4-6 E) 6-8

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The K_a for formic acid HCOOH is $1.77 \cdot 10^{-4}$. Use this information to answer the following six related questions.

40.) What is the $[H_3O^+]$ of a 0.20 M formic acid solution?

A) $5.9 \cdot 10^{-3}$ B) $7.7 \cdot 10^{-4}$ C) $1.77 \cdot 10^{-4}$ D) $2.9 \cdot 10^{-1}$ E) $1.1 \cdot 10^{-5}$

41.)What is the pH of a 0.20 M formic acid solution?

A) 2.2 B) 3.4 C) 4.5 D) 5.6 E) 6.7

42.) What is the pH of a 0.20 M solution of formic acid when it is titrated to one-half its equivalence point (assume no volume change)?

A) 2.56 B) 3.75 C) 4.85 D) 5.95 E) 7.00

43.) What is the conjugate base of formic acid?

A) HCl B) OH^- C) $HCOO^-$ D) HCOOH E) NaCl

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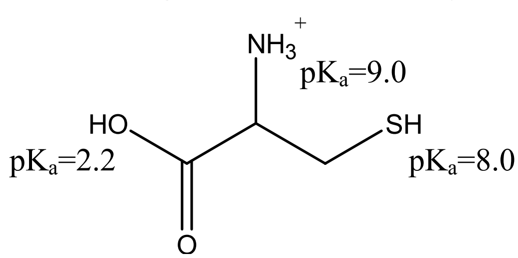
44.) What is K_b for the conjugate base of formic acid?

A) $2.80 \cdot 10^{-8}$ B) $4.75 \cdot 10^{-10}$ C) $3.70 \cdot 10^{-9}$ D) $5.65 \cdot 10^{-11}$ E) $6.90 \cdot 10^{-7}$

45.) What is the pH of a 0.20 M formic acid solution when it is titrated to equivalence point (assume no volume change)?

A) 5.5 B) 6.5 C) 7.5 D) 8.5 E) 9.5

46.) What is the total effective charge on the amino acid cysteine at pH 5.0?



A) +1 B) 0 C) -1

47.) What is the pH at the equivalence point of a titration of a weak base with a strong acid?

A) pH>7 B) pH=7 C) pH<7 D) Can't determine

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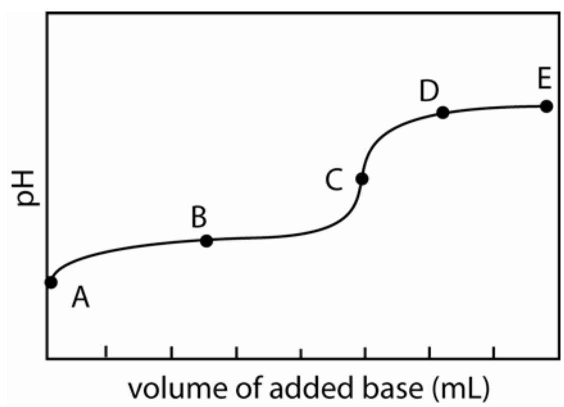
48.) What is the pH of hot (~80°C) water?

A) pH>7 B) pH=7 C) pH<7 D) Can't determine

49.) Which of the following combinations will produce a buffer with a pH=10? The K_b of NH_3 is $1.8 \cdot 10^{-5}$.

A) 50 mL of 0.74 M NH_4^+ and 50 mL of 1.0 M NH_3
B) 50 mL of 1.0 M NH_4^+ and 50 mL of 0.74 M NH_3
C) 50 mL of 0.18 M NH_4^+ and 50 mL of 1.0 M NH_3
D) 50 mL of 1.0 M NH_4^+ and 50 mL of 0.18 M NH_3
E) 50 mL of 4.7 M NH_4^+ and 50 mL of 3.0 M NH_3

The titration curve of a weak acid with NaOH is shown below. Use this titration curve for the following questions.



50.) Which point(s) corresponds to the equivalence point? C

51.) Which point(s) corresponds to the maximum buffering region? B

52.) Which point(s) corresponds to the point where the pH=pKa? B

53.) Which point(s) corresponds to a region where the pH depends primarily on the properties of HA? A B C

54.) Which point(s) corresponds to a region where the pH depends only on [NaOH]?

D E

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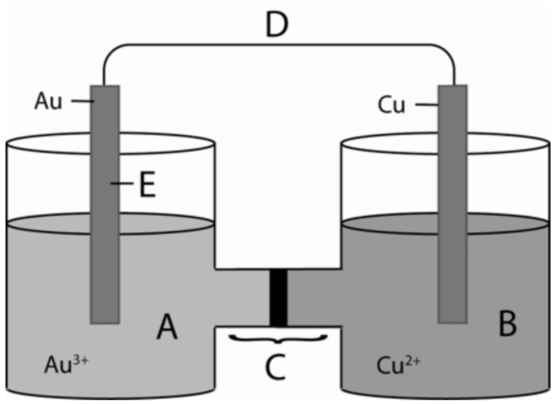
55.) Which solution will have the highest pH?

A) 10^{-3} M HCl   B) 10^{-3} M NaOH   C) 10^{-13} M HCl

Consider the galvanic cell shown below for the following questions. The standard reduction potentials are listed below the figure. Assume that all concentrations are 1.0 M and that all partial pressures are 1.0 atm. Use the capitalized letters (A-E) to answer each question.



$Au^{3+} + 3e^- \rightarrow Au$ $E^o = 1.50$ V

$Cu^{2+} + 2e^- \rightarrow Cu$ $E^o = 0.34$ V

56.) Where is oxidation taking place? Mark all that apply. B

57.) Where is reduction taking place? Mark all that apply. A

58.) What is the value of E^o (in volts) for the cell?

A) 1.50   B) 0.34   C) 1.16   D) 1.84   E) 1.98

59.) Where are electrons flowing? Mark all that apply.

A) From A to B
B) From B to A
C) Through C
D) Through D
E) Cannot determine from the information given.

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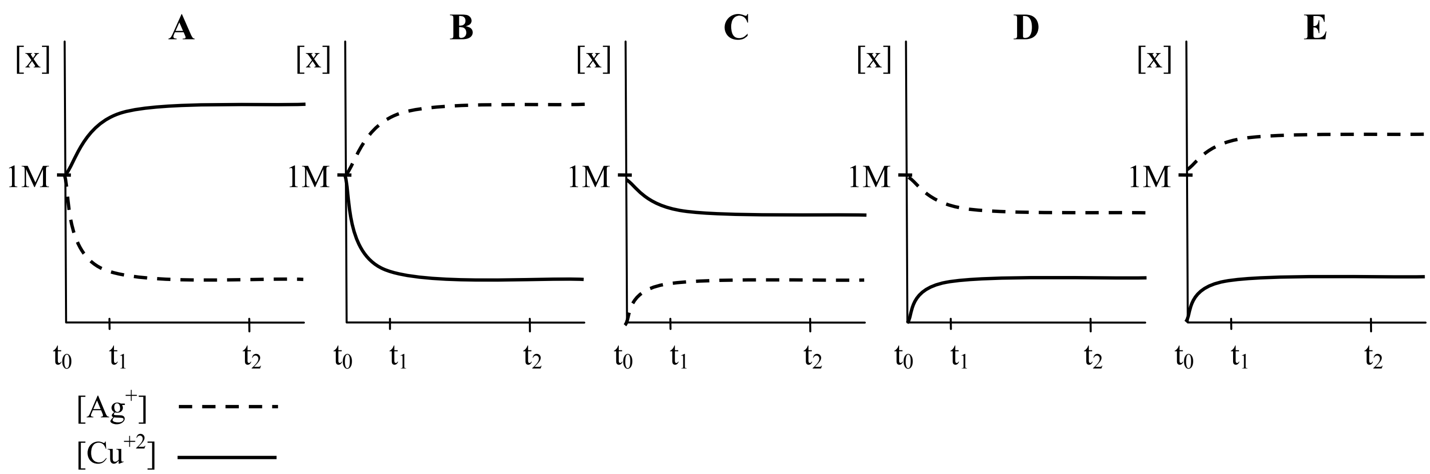
Consider the plots of concentration vs. time for the silver and copper ion concentrations starting from a variety of initial conditions at 298K in the cell arrangement:

Cu^{+2} (aq) + $2e^-$ → Cu (s) ΔE° = 0.34 V

Ag^+ (aq) + e^- → Ag (s) ΔE° = 0.80 V



60.) For which plot(s) are the initial product and reactant conditions standard states? Mark all that apply. A B

61.) Which plot(s) represent reactions that truly proceed spontaneously from their standard states? Mark all that apply. A

62.) For the reaction in plot C, what is ΔG for the reduction of Ag^+ by Cu at time t_0?

A) ΔG > 0 B) ΔG = 0 C) ΔG < 0 D) ΔG = ΔG° E) none of these

63.) For the reaction in plot C, what is ΔG at time t_2?

A) ΔG > 0 B) ΔG = 0 C) ΔG < 0 D) ΔG = ΔG° E) none of these

64.) Which is true for the reaction in plot A at time t_1?

A) Q > K B) Q = K C) Q < K D) Q = 0 E) none of these

65.) Which is true for the reaction in plot A at time t_2?

A) Q > K B) Q = K C) Q < K D) Q = 0 E) none of these

66.) What is the relationship between Q at t_2 in plot A vs. Q at t_2 in plot D?

A) Q(A) = Q(D)
B) Q(A) > Q(D)
C) Q(A) < Q(D)
D) Cannot be determined

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Consider the combustion of formaldehyde CH_2O and the data below for the following five questions.

I. $CH_2O\ (g) + O_2\ (g) \rightarrow CO_2\ (g) + H_2O\ (l)$

II. $4\ H^+ + 4\ e^- + O_2\ (g) \rightarrow 2\ H_2O\ (l)$ $\Delta E^\circ = 1.23$ V

Compound	$\Delta G^\circ f$ (kJ/mol)
CH_2O (g)	-109
CO_2 (g)	-393
H_2O (l)	-237

67.) Which compound is reduced in reaction **I**?

A) CH_2O B) H_2O C) O_2 D) CO_2 E) none of these

68.) What is the change in oxidation number of the carbon in reaction **I**?

A) -4 B) -1 C) 0 D) 1 E) 4

69.) What is ΔG° for the combustion of formaldehyde (kJ/mol)?

A) 224
B) -521
C) 96
D) -150
E) More data are required.

70.) How many electrons are required to balance the half reaction $CH_2O \rightarrow CO_2$ in acidic solution?

A) 1 B) 2 C) 3 D) 4 E) 5

71.) What is the standard half cell potential (in volts) for the CH_2O oxidation?

A) 1.7
B) 0.76
C) 0.12
D) 3.33
E) 1.69

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The overall reaction and equilibrium constant value for a hydrogen-oxygen fuel cell at 298 K is:

$$2H_2(g) + O_2(g) \leftrightarrow 2H_2O(l) \quad K = 1.28{\cdot}10^3$$

72.) What is the value of ΔE^o (in volts) for this reaction?

A) 0.0459 B) 0.184 C) $4.53{\cdot}10^{-4}$ D) 9.1610^{-2} E) 6.1210^{-2}

73.) What are the signs for ΔH^o and ΔS^o for the reaction?

A) ΔH^o is positive and ΔS^o is positive.
B) ΔH^o is positive and ΔS^o is negative.
C) ΔH^o is negative and ΔS^o is positive.
D) ΔH^o is negative and ΔS^o is negative.
E) Cannot determine from the information given.

74.) What will happen to the maximum amount of work obtained from the fuel cell reaction as the temperature is increased?

A) The work increases.
B) The work decreases.
C) The work remains the same.
D) Cannot determine from the information given.

75.) When ^{73}Ga decays to form ^{73}Ge, what is the other product?

A) beta particle
B) alpha particle
C) gamma ray
D) positron
E) antiparticle

76.) One type of commercial smoke detector contains a minute amount of radioactive americium-241 (^{241}Am), which decays by a-particle production. The complete decay of ^{241}Am involves successively, α, α, β, α, α, β, α, α, α, β, α and β production. What is the final stable nucleus produced in this decay series?

A) $^{209}_{83}Bi$ B) $^{209}_{79}Au$ C) $^{209}_{75}\mathrm{Re}$ D) $^{209}_{95}Am$ E) $^{209}_{82}Pb$

77.) The half-life of ^{241}Am is 432.2 years and it decays primarily by the emission of alpha particles. How many alpha particles are emitted each second by a 5.0 g sample of ^{241}Am?

A) $5.1{\cdot}10^{11}$ B) $2.6{\cdot}10^{9}$ C) $1.5{\cdot}10^{14}$ D) $6.4{\cdot}10^{11}$ E) $3.8{\cdot}10^{10}$

78.) $^{245}_{95}$Am decays via β^- decay, and then the resulting nucleus decays by α decay to which of the following?

A) ^{241}U B) ^{241}Pu C) ^{243}Pu D) ^{240}U

Bromocresol green is an acid-base indicator that undergoes a color change when it gains or loses a proton (H^+). You have used this indicator frequently in lab when titrating a weak base with a strong acid. The two forms of the indicator are blue (high pH) and yellow in solution. The indicator is represented below as Ind^-.

$$H_3O^+ (aq) + Ind^- (aq) \leftrightarrows HInd (aq) + H_2O (l)$$

79.) Which species is yellow in solution?

A) H_3O^+
B) Ind^-
C) HInd
D) H_2O

80.) What is the pKa of the indicator if at pH 6.5 the [yellow]=0.00015 M and [blue]=0.01 M.

A) 2.21 B) 3.75 C) 4.68 D) 5.88 E) 8.32