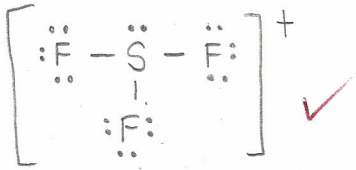
Chem1B, Fall11, MC, Lec ExamFinal 101-2=99 45 144/152 Name KEY

Read the questions carefully to understand it, before answering on the question paper. Write clearly and concisely. **Write set-up equation, then put the raw numbers with units before doing your calculation.** Use the reverse side of your answer paper as scratch. Ask your instructor if you don't understand anything. A periodic table & some formulas are on the back. (Total pts.= 101 + (3*17=) 51 = 152).

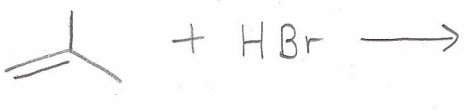
SHORT ANSWER. To get full points, show all your work in details with set up equation and units.

1) Draw the Lewis structure of SF_3^+ (4 pts.). 1) _____

$6+3(7)-1 = 26\ e^-$



2) Draw the structures of the reactants and major product of the reaction between 2-methyl propene and HBr (6 pts.) and name the major product (3 pts.) 2) _____



2-bromo-2-methyl propane

3) If you are given a 5.0L of 0.05M sodium benzoate solution, then how many grams of benzoic acid (C_6H_5COOH) would you mix to get a buffer of pH = 4.5? Ka of benzoic acid is 6.3×10^{-5}. (8 pts) 3) _____

MM= 6(12)+5 +12+2(16)+1 = 122g/mol

$K_a = 6.3 \times 10^{-5}$

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

$4.5 = -\log(6.3 \times 10^{-5}) + \log \frac{0.05\ M}{[HA]}$

$4.5 - 4.2 = \log \frac{0.05}{[HA]}$

$1.99223 = \frac{0.05}{[HA]}$

$[HA] = [C_6H_5COOH] = 0.025\ M$

$0.025 \frac{mol}{L} \times 5.0L = 0.125487\ mol$

$0.125487\ mol \times \frac{122g}{mol} = \boxed{15.3g}$

4) If a rate law is second order (reactant), doubling the amount of reactant will _____ the reaction rate (3 pts.). 4) _____

$Rate = k[A]^2$

$4(Rate) = k[2A]^2 \Rightarrow$ quadruple by

$Rate = k[A]^m[B]^n$

5) The initial rate of the reaction A + B -----> C was measured at several different concentrations of the reactants. Following formal methods, (a) calculate the rate law for the reaction (6 pts.) and (b) The magnitude of the rate constant (4 pts.). 5) _____

Experiment	Initial Concentrations [A] (M)	[B] (M)	Initial Rate (M s^{-1})
1	0.10	0.10	4.0×10^{-5}
2	0.10	0.20	4.0×10^{-5}
3	0.20	0.10	16.0×10^{-5}

n: 1 → 2; m: 1 → 3

$$\frac{k(0.10)^m(0.20)^n}{k(0.10)^m(0.10)^n} = \frac{4.0\times10^{-5}}{4.0\times10^{-5}}$$

$$\left(\frac{0.2}{0.1}\right)^n = 1$$

$2^n = 1$

$n = 0$ ✓

$$\frac{k(0.20)^m(0.10)^n}{k(0.10)^m(0.10)^n} = \frac{16\times10^{-5}}{4\times10^{-5}}$$

$$\left(\frac{0.2}{0.1}\right)^m = 4$$

$2^m = 2^2$

$m = 2$ ✓

$Rate = k[A]^2$

$4.0\times10^{-5}\ \frac{M}{s} = k(0.1M)^2$

$K = 0.004\ /M\cdot s$

$\boxed{Rate = 0.004[A]^2}$ ✓

6) Equilibrium was established when a mixture of 0.20 mol of NO(g), 0.10 mol of H_2(g), and 0.20 mol of H_2O(g) is placed in a 2.0-L vessel at 400 K. The equilibrium reaction is : 2 NO(g) + 2 H_2(g) <——> N_2(g) + 2 H_2O(g). If at equilibrium [NO] = 0.062 *M*, then calculate K_p.(8 pts) 6) _____

$2NO + 2H_2 \rightleftharpoons N_2 + 2H_2O$

	NO	H_2	N_2	H_2O
C	0.1 M	0.05 M	0	0.1 M
Δ	−2x	−2x	+x	+2x
f	0.062	0.05−2x (0.012)	x (0.019)	0.1+2x (0.138)

$0.1 - 2x = 0.062$

$2x = 0.038$

$x = 0.019$ M ✓

$$K_c = \frac{[N_2][H_2O]^2}{[NO]^2[H_2]^2} = \frac{(0.019)(0.138)^2}{(0.062)^2(0.012)^2} = 653.681$$ ✓

$K_p = K_c(RT)^{\Delta n}$

$= 653.68\left[\left(0.0821\ \frac{atm\cdot L}{mol\cdot K}\right)(400\ K)\right]^{3-4}$

$= \boxed{19.9}$ ✓

$$H_2O \rightleftharpoons H_3O^+ + OH^-$$

7) Calculate $\Delta G°$ (in kJ/mol) for the autoionization of water at 25°C. $K_W = 1.0 \times 10^{-14}$ (5 pts.) 7) _____

$$\Delta G° = -RT \ln K$$
$$= -\left(8.3145 \frac{J}{mol \cdot K}\right) \ln (1.0 \times 10^{-14}) (298\ K)$$
$$= 79872.288\ J/mol = \boxed{79.9\ kJ/mol}$$

8) Calculate the mass of Lithium metal produced when molten Lithium Chloride is electrolyzed in a cell with a current of 5.5×10^4 A flowing for a period of one day. Assume the electrolytic cell is 85% efficient (6 pts.). 8) _____

$LiCl \Rightarrow 1e^-/Li$

$I = 5.5 \times 10^4 C/s$

$$t = 1 day \times \frac{24 hr}{day} \times \frac{60 min}{hr} \times \frac{60 s}{min} = 86400\ s$$

$$86400\ s \times \frac{5.5 \times 10^4 C}{s} \times \frac{mol\ e^-}{9.648 \times 10^4 C} \times 0.85 \times \frac{mol\ Li}{mol\ e^-} \times \frac{6.941 g\ Li}{mol\ Li} = \boxed{29058.9 g\ Li}$$

9) Strontium-90 is a byproduct in nuclear reactors fueled by the radioisotope uranium-235. The half-life of strontium-90 is 28.8 yr. What percentage of a strontium-90 sample remains after 70.0 yr (8 pts.)? 9) _____

$$t_{\frac{1}{2}} = \frac{0.693}{K}$$
$$28.8 = \frac{0.693}{K}$$
$$K = 0.0240625$$

$$\ln\left(\frac{N_t}{N_0}\right) = -kt$$
$$\ln\left(\frac{N_t}{N_0}\right) = -(0.0240625)(70.0)$$
$$\frac{N_t}{N_0} = e^{-(0.0240625)(70.0)}$$
$$= .18556$$
$$100 \times \frac{N_t}{N_0} = \boxed{18.6\%}$$

$\frac{^{238}U}{^{206}Pb} = \frac{3.1949\,g}{1\,g}$ $\quad t_{\frac{1}{2}} = 4.5\times10^{9} = \frac{0.693}{K}$ $\quad K = 1.54\times10^{-10}$

10) If in a sample of rock the uranium-238 to lead-206 ratio is 3.1949, then calculate the age of the rock in years. The half-life of for the decay of uranium-238 to lead-206 is 4.5×10^9 yr. (8 pts.) 10) _____

$$\ln\left(\frac{N_t}{N_0}\right) = -kt$$

$$\ln\left(\frac{3.1949\,g\ ^{238}U}{3.1949\,g + \frac{238g\ U}{206Pb}(1\,g\,Pb)}\right) = -(1.54\times10^{-10})t$$

$$\ln(0.7344) = -(1.54\times10^{-10})t$$

$$t = 2004384305 \Rightarrow \boxed{2.0\times10^{9}\ yr}$$

11) Calculate the nuclear binding energy (Joules/Nucleon) of Helium-4 **nucleus** . $^{4}_{2}He$ 11) _____
(Given: Mass of a helium **nucleus** = 4.0015 amu; Mass of a proton = 1.00728 amu; Mass of a neutron = 1.00866 amu; Mass of an electron: 5.4858 x 10-4 amu) (8 pts.).

mass defect $= [2(1.00728\ amu) + 2(1.00866\ amu)] - 4.0015 = 0.03038\ amu$

$$0.03038\ amu \times \frac{1\,g}{6.023\times10^{23}\ amu} \times \frac{kg}{1000\,g} = 5.043998\times10^{-29}\ kg$$

$J = \frac{kg\cdot m^2}{s^2}$ $\quad E = mc^2 = (5.043998\times10^{-29}\ kg)(2.997\times10^{8}\ \frac{m}{s})^2 = 4.53\times10^{-12}\ J$

$$NBE = \frac{4.53\times10^{-12}\ J}{4\ nucleon} = \boxed{1.13\times10^{-12}\ J/nucleon}$$

12) The amount of fissionable material necessary to maintain a chain reactions is called the _____ . (2 pts) 12) _____

critical mass

13) What is the oxidation state of the iron atom in $CaNa[Fe(CN)_6]$? (2 pts) 13) _____

+3 (+2 +1 +3 −6)

14) Six-coordinate complexes generally have _____ geometry (2 pts). 14) _____

octahedral

15) A compound that can occupy two coordination sites is a (an) _____ ligand. (2 pts) 15) _____

bidentate or polydentate

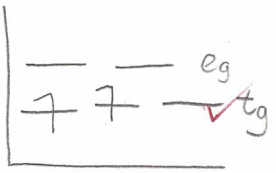
16) Write d electron configuration of the metal ion, draw the crystal-field energy-level diagrams (to the right of the formula) and show the placement of electrons for the following complexes: (4 x 4 = 16 pts.) 16) _____

(a) $[VCl_6]^{3-}$

+3, -6

$V: [Ar]\,4s^2 3d^3$

$V^{3+}: [Ar]\,3d^2$

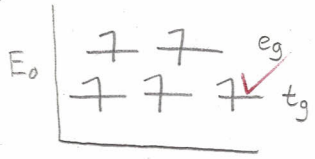


(b) $[FeF_6]^{3-}$ (a high-spin complex)

+3, -6

$Fe: [Ar]\,4s^2 3d^6$

$Fe^{3+}: [Ar]\,3d^5$

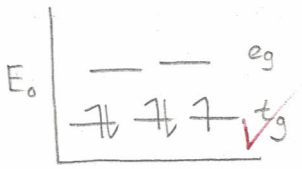


(c) $[Ru(bipy)_3]^{3+}$ (a low-spin complex)

+3

$Ru: [Kr]\,5s^2 4d^6$

$Ru^{3+}: [Kr]\,4d^5$

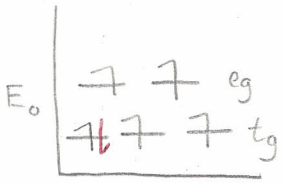


(d) $[PtBr_6]^{2-}$

+4 -6

$Pt: [Xe]\,6s^2 4f^{14} 5d^8$

$Pt^{4+}: [Xe]\,4f^{14} 5d^6$

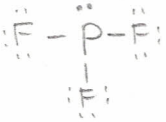


Weak field ligand, high spin

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question (3 pts each).

$5+3(7)=26e^-$

17) The Lewis structure of PF_3 shows that the central phosphorus atom has _____ nonbonding electron pairs and _____ bonding electron pairs. 17) E



A) 1, 2 B) 3, 1 C) 2, 2 D) 3, 3 E) 1, 3

18) Pentane has _____ structural isomers. 18) E

A) 4 B) 0 C) 2 D) 1 E) 3

19) Of the units below, _____ is appropriate for a first-order reaction rate constant. 19) E

A) $M\ s^{-1}$
B) $L\ mol^{-1}\ s^{-1}$
C) mol/L
D) $M^{-1}\ s^{-1}$
E) s^{-1}

$R = K[A] = \frac{M}{S}$

20) What change will be caused by addition of a small amount of HCl to a solution containing fluoride ions and hydrogen fluoride? 20) C

$\downarrow F^-$ $HF \uparrow$

A) The concentration of fluoride ions will increase as will the concentration of hydronium ions.
B) The concentration of hydronium (H_3O^+) ions will increase significantly.
C) The concentration of fluoride ion will decrease and the concentration of hydrogen fluoride will increase.
D) The concentration of hydrogen fluoride will decrease and the concentration of fluoride ions will increase.
E) The fluoride ions will precipitate out of solution as its acid salt.

21) Formation of solutions where the process is endothermic can be spontaneous provided that _____. 21) C

A) the solvent is water and the solute is a gas
B) they are accompanied by another process that is exothermic
C) they are accompanied by an increase in disorder — $\Delta S = \oplus$
D) the solvent is a gas and the solute is a solid
E) they are accompanied by an increase in order $\Delta S = \ominus$

$\Delta G^\circ = \Delta H - T\Delta S$
$\oplus$

22) Which transformation could take place at the cathode of an electrochemical cell? 22) A

A) $HSO_4^- \rightarrow H_2SO_3$ (+1 +6 -8 → +2 +4 -6)
B) $Br_2 \rightarrow BrO_3^-$ (0 → +5)
C) $MnO_2 \rightarrow MnO_4^-$ (+4 → +7)
D) $NO \rightarrow HNO_2$ (+2 → +1, +3 -4)
E) $Mn^{2+} \rightarrow MnO_4^-$ (+7)

→ Reduction, Cat
Oxidation, Anode

Table 20.2

Half-reaction	E° (V)
$Cr^{3+}(aq) + 3e^- \rightarrow Cr(s)$	−0.74
$Fe^{2+}(aq) + 2e^- \rightarrow Fe(s)$	−0.440
$Fe^{3+}(aq) + e^- \rightarrow Fe^{2+}(s)$	+0.771
$Sn^{4+}(aq) + 2e^- \rightarrow Sn^{2+}(aq)$	+0.154

23) Which of the following reactions will occur spontaneously as written? 23) C

A) $3Fe^{2+}(aq) \rightarrow Fe(s) + 2Fe^{3+}(aq)$

B) $Sn^{4+}(aq) + Fe^{3+}(aq) \rightarrow Sn^{2+}(aq) + Fe^{2+}(aq)$

C) $3Sn^{4+}(aq) + 2Cr(s) \rightarrow 2Cr^{3+}(aq) + 3Sn^{2+}(aq)$ $(0.154) - (-0.74) = (+)$

D) $3Fe(s) + 2Cr^{3+}(aq) \rightarrow 2Cr(s) + 3Fe^{2+}(aq)$ $(-0.74) - (-0.44) = (-)$

E) $Sn^{4+}(aq) + Fe^{2+}(aq) \rightarrow Sn^{2+}(aq) + Fe(s)$

24) Consider an electrochemical cell based on the reaction: 24) D

$$2H^+(aq) + Sn(s) \rightarrow Sn^{2+}(aq) + H_2(g)$$

Which of the following actions would not change the measured cell potential?

A) increasing the tin (II) ion concentration in the anode compartment

B) lowering the pH in the cathode compartment

C) increasing the pressure of hydrogen gas in the cathode compartment

D) addition of more tin metal to the anode compartment

E) Any of the above will change the measured cell potential.

25) Which of these nuclides is most likely to be radioactive? 25) A

A) $^{243}_{95}Am$ B) $^{39}_{19}K$ C) $^{27}_{13}Al$ D) $^{127}_{53}I$ E) $^{209}_{83}Bi$

$\frac{148}{95}$ $\frac{74}{53}$ $\frac{126}{83}$ A# > 83

$K = \frac{0.693}{22.3} = 0.03108$ 26) ^{210}Pb has a half-life of 22.3 years and decays to produce ^{206}Hg. If you start with 7.50 g of 26) E

$\ln\left(\frac{A_t}{7.50}\right) = -0.03108(17.5)$ ^{210}Pb, how many grams of ^{206}Hg will you have after 17.5 years?

$A_t = 4.35$ left A) 1.71 B) 3.15 C) 4.35 D) 0.0600 E) 3.09

$3.15g\left(\frac{206g\ Hg}{210g\ Pb}\right) = 3.09$

27) The mass of a proton is 1.00728 amu and that of a neutron is 1.00867 amu. What is the mass defect (in amu) of a $^{60}_{27}Co$ nucleus? (The mass of a cobalt-60 nucleus is 59.9338 amu.) 27) D

$27(1.00728) + 33(1.00867) - 59.9338 = 0.54887$

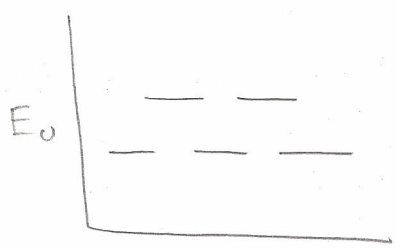
_____.?

A) 27.7830 B) 0.4827 C) 0.0662 D) 0.5489 E) 0.5405

28) Which one of the following ions cannot form both a high spin and a low spin octahedral complex ion? 28) A

A) Cr^{3+} B) Cr^{2+} C) Mn^{3+} D) Co^{2+} E) Fe^{3+}

$3e^-$ $4e^-$ $4e^-$ $7e^-$ $5e^-$



29) During the formation of a coordination compound, ligands act as _____. 29) E

A) Arrhenius bases
B) BrØnsted bases
C) Arrhenius acids
D) Lewis acids
E) Lewis bases

donates e^-

30) Formation of a complex species of M^{n+} metal ion with ligands often _____. 30) C E

A) reduces availability of the free M^{n+} ions in solution
B) may cause changes in the ease with which M^{n+} is reduced or oxidized
C) alters original physical properties of M^{n+}
D) "masks" original chemical properties of both the M^{n+} ion and the ligands
E) all of the above

31) Based on electron configuration, which is most likely colorless? 31) C

A) $[Cu(NH_3)_4]^{2+}$
B) $[Cr(NH_3)_5Cl]^{2+}$
C) $[Cd(NH_3)_4]^{2+}$
D) $[Ni(NH_3)_6]^{2+}$
E) $[Co(NH_3)_6]^{2+}$

32) Which one of the following species is paramagnetic? 32) B

A) Cu^+ B) Cr^{3+} C) Ag^+ D) Zn E) Ca

8e 8e⁻

33) Which one of the following complexes would most likely have tetrahedral geometry? 33) B A

A) $[NiCl_4]^{2-}$ Ni^{2+} ⇒ 8d e⁻ square planar
B) $[Pt(NH_3)_2Cl_2]$ Pt^{4+}
C) $[Cr(NH_3)_6]^{3+}$
D) $[Fe(CN)_6]^3$
E) $[Co(H_2O)_6]^{2+}$