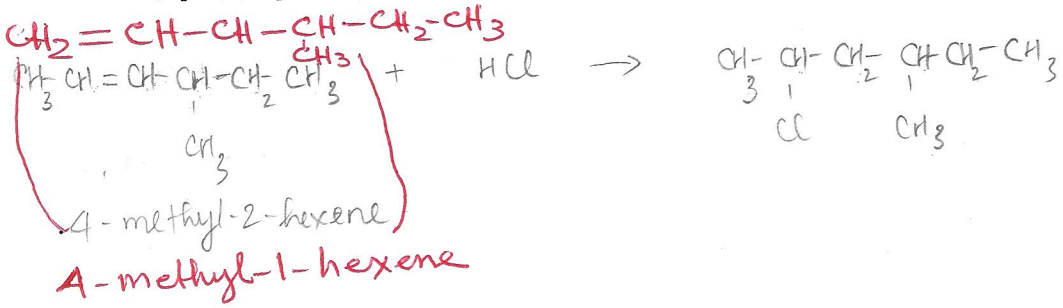
Chem1B, Spring16, MC, FinalTest 64-9=55 72/127/148

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.= 64 + (3*28=) 84 = 148).

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

1) The molecule 2-chloro-4-methylhexane, the product, is made by addition of HCl to an alkene, the reactant . Write a balanced chemical equation using condensed or skeleton structures of the reactants (3 pts.) and products (3 pts.) for this reaction. Also name the reactant (3 pts.) (10 pts. tot.). 1) _____



-1

2) 250mL of a buffer of pH 12.25 was made by dissolving Na_2HPO_4 and Na_3PO_4 in water. A buffer constitutes a weak acid and its conjugate base. Which is the acid here (1 pts.) and which is the conjugate base (1 pts.). Write the formula you would use to calculate the pH of the buffer (1 pt.). If the concentration of Na_3PO_4 is 0.4 M, what **mass (in grams) of Na_2HPO_4** is present in that **250mL** buffer. ($K_{a3} = 4.2 \times 10^{-13}$) (8 pts.) 2) _____

Acid: HPO_4^-

conjugate base: PO_4^{3-}

H-H equation: $pH = pKa + \log \frac{[PO_4^{3-}]}{[HPO_4^-]}$.

$pKa = -\log Ka_3$

$= -\log 4.2 \times 10^{-13}$

$= 12.38$

$[PO_4^{3-}] = 0.4\ M$

$\Rightarrow 12.25 = 12.38 + \log \frac{0.4}{[HPO_4^-]} \Rightarrow \log \frac{0.4}{[HPO_4^-]} = -0.13$

$\Rightarrow [HPO_4^-] = 0.54\ M$ ✓

$\Rightarrow n_{HPO_4^-} = 0.54\ M \times 0.25\ L = 0.135\ mol$

$m_{Na_2HPO_4} = 0.135\ mol \times 142\ g/mol = 19.17\ g$ ✓

3) 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)

3) 19.9

$[NO]_i = \frac{0.20}{2.0} = 0.1\,M$

$[H_2]_i = \frac{0.10}{2.0} = 0.05\,M$

$[H_2O]_i = \frac{0.20}{2} = 0.1\,M$

	$2NO(g)$	$+\ 2H_2(g)$	$\rightleftharpoons N_2(g)$	$+\ 2H_2O(g)$
I	0.1 M	0.05	—	0.1 M
C	$-x$	$-x$	$+\frac{1}{2}x$	$+\ x$
E	$0.1-x$	$0.05-x$	$\frac{1}{2}x$	$0.1+x$

At equilibrium: $[NO] = 0.062 \Rightarrow 0.1 - x = 0.062 \Rightarrow x = 0.038$

$$\Rightarrow K_c = \frac{[H_2O]^2[N_2]}{[H_2]^2[NO]^2} = \frac{(0.1+0.038)^2\left(\frac{1}{2}\cdot 0.038\right)}{(0.05-0.038)^2(0.1-0.038)^2} = 653.68$$

$$K_p = K_c(RT)^{\Delta n} = 653.68\,(0.082 \cdot 400)^{(2+1-2-2)} = 19.9$$

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

4) Critical Mass

−2

5) What is the coordination number of the iron atom in CaNa[Fe(CN)$_6$] (2 pts.)?

5) 6

+6

6) The most common coordination numbers are 4, 6 (4 pts.).

6) 4 & 6

−2

7) Calculate the nuclear binding energy (Joules/Nucleon) of Helium-4 nucleus .
(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.)

7) _____

^4_2He →

Mass defect: $\Delta m = 4.0015\ amu - 2 \times 1.00728\ amu - 2 \times 1.00866\ amu$

$= -0.03038\ amu$

$$E = mc^2 = 0.03038\ amu \times \frac{1\ g}{6.022\times10^{23}\ amu} \times 10^{-3}\ kg \times (3.00\times10^8)^2$$

$= 2.7342 \times 10^{15}\ J/nucleon = 4.534\times10^{-12}\ J$

−4

$$\therefore \text{Nuclear Binding Energy} = \frac{4.534\times10^{-12}\ J}{4\ nucleons} = 1.13\times10^{-12}\ J/nucleon$$

8) 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.)? 8) 18.5%

$t_{1/2} = 28.8\ yr \qquad t_{1/2} = \frac{0.693}{k} \Rightarrow k = \frac{0.693}{t_{1/2}} = \frac{0.693}{28.8} = 0.0241$

$\ln \frac{N_t}{N_0} = -k.t$

$\Rightarrow \frac{N_t}{N_0} = e^{-kt} = e^{-0.0241 \times 70.0} = 0.185 = 18.5\%$ ✓

9) 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.). 9) 290 kg

$Li^+ + 1e \longrightarrow Li$

$A = 5.5 \times 10^4$

$t = \text{one day} = 24 \times 60 \times 60 = 86400\ s$

$C = A \times t \Rightarrow 5.5 \times 10^4 \times 86400\ C \cdot \frac{1\ mole}{96485\ C} \times \frac{1\ mol\ Li}{1\ mole^-} \times 6.941\ g/mol^{Li} \times 85\%$

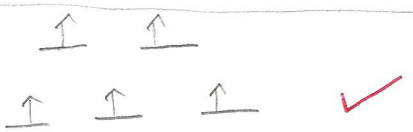
$= 290547\ g = 290.547\ kg$ ✓

10) Write d electron configuration of the metal ion (2 pts.), draw the crystal-field energy-level diagrams (to the right of the formula, 1 pt.) and show the placement of electrons (1 pts.) for the following complexes: (2 x 4 = 8 pts. total) 10) _____

(a) $[VCl_6]^{3-}$: V^{+3} : $[Ar]\ 4s^0\ 3d^2$

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

Fe^{+3}: $[Ar]\ 4s^0\ 3d^5$



MULTIPLE CHOICE. On your scantron start from same bubble number as the M/C question number. Choose the one alternative that best completes the statement or answers the question (3 pts each).

11) Which process has $\Delta S > 0$? 11) D

A) $H_2O(g) \rightarrow H_2O(l)$
B) $2Hg(l) + O_2(g) \rightarrow 2HgO(s)$
C) $CaO(s) + CO_2(g) \rightarrow CaCO_3(s)$
D) $2Na_2O_2(s) + 2H_2O(s) \rightarrow 4NaOH(aq) + O_2(g)$

A) B) C) (D)

12) Which combination represents a chemical reaction that is spontaneous at any temperature? 12) B

$\Delta G = \Delta H - T\Delta S$
$\Delta G < 0$

A) $\Delta H < 0$ and $\Delta S < 0$ B) $\Delta H < 0$ and $\Delta S > 0$
C) $\Delta H > 0$ and $\Delta S < 0$ D) $\Delta H > 0$ and $\Delta S > 0$

A) (B) C) D)

$s \rightarrow l$
$l \rightarrow g$
$s \rightarrow l \rightarrow g$

13) Which changes is endothermic? 13) C

A) $CO_2(g) \rightarrow CO_2(s)$ B) $CO_2(g) \rightarrow CO_2(l)$
C) $CO_2(s) \rightarrow CO_2(g)$ D) $CO_2(l) \rightarrow CO_2(s)$

A) B) C) D)

14) Calculate $\Delta G°$ for the reaction (F = 96,480 C/mol. e): 14) A

$3Pb + 2Fe^{+3} \leftrightarrow 3Pb^{+2} + 2Fe \quad E° = 0.094\ V$

A) -54 kJ B) -27 kJ C) -18 kJ D) -9.0 kJ

$Fe^{3+} + 3e \rightarrow Fe$
$Pb \rightarrow Pb^{2+} + 2e$
$n = 6$

A) B) C) $\Delta G = -nF\Delta E$ D)

15) Which will shift this equilibrium to the reactants? 15) A

$2NOBr(g) \leftrightarrow 2NO(g) + Br2(l) \quad \Delta H° = 30\ kJ.\ mol^{-1}$

$+\Delta H°$ $\Delta H° > 0$

A) decrease the temperature B) decrease the pressure
C) increase [NOBr] D) add a catalyst

A) B) C) D)

16) If the equilibrium constant for a reaction is 1.6×10^{-17}, then

A) at equilibrium [Reactants] >> [Products].
B) at equilibrium [Reactants] << [Products].
C) it takes a long time to reach equilibrium.
D) equilibrium is reached very rapidly

16) A

$K = \frac{[R]}{[P]} \ll 1$

A) B) C) D)

17) What is the pH of a buffer solution in which the molar concentration of acetic acid is 0.15 M and the molar concentration of the acetate ion is 0.55 M? K_a of acetic acid = 1.8×10^{-5}.

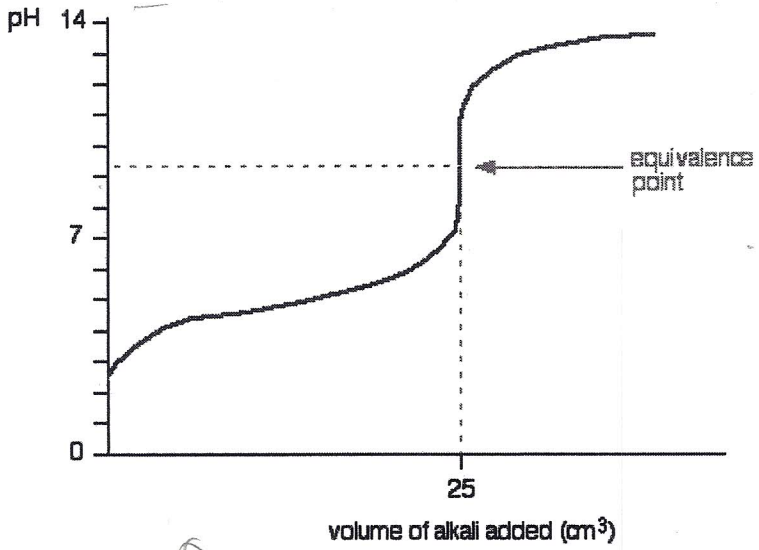
A) 4.74 B) 5.01 C) 5.30 D) 12.93

17) C

$pH = pKa + \log \frac{B}{A}$

A) B) C) D)

18) What is the approximate pK_a of the weak acid being titrated?

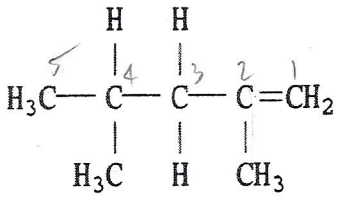


A) 2.6 B) 4.5 C) 9.2 D) 13

18) B

A) B) C) D)

19) What is the name of the compound below? 19) C



A) 2,4-methylbutene
B) 2,4-ethylbutene
C) 2,4-dimethyl-1-pentene
D) 2,5-dimethylpentane
E) 2,4-dimethyl-4-pentene

g → l → g · endo

20) Of the following, _____ is an exothermic process. 20) A

A) freezing
B) subliming
C) melting
D) boiling
E) All of the above are exothermic.

21) For a first-order reaction, a plot of _____ versus _____ is linear. 21) D

A) t, $\frac{1}{[A]_t}$ B) $\frac{1}{[A]_t}$, t C) ln $[A]_t$, $\frac{1}{t}$ D) ln $[A]_t$, t E) $[A]_t$, t

22) The half-reaction occurring at the anode in the balanced reaction shown below is _____. 22) B

$$3MnO_4^-(aq) + 24H^+(aq) + 5Fe(s) \rightarrow 3Mn^{2+}(aq) + 5Fe^{3+}(aq) + 12H_2O(l)$$

A) $MnO_4^-(aq) + 8H^+(aq) + 5e^- \rightarrow Mn^{2+}(aq) + 4H_2O(l)$
B) $Fe(s) \rightarrow Fe^{3+}(aq) + 3e^-$
C) $Fe^{2+}(aq) \rightarrow Fe^{3+}(aq) + e^-$
D) $2MnO_4^-(aq) + 12H^+(aq) + 6e^- \rightarrow 2Mn^{2+}(aq) + 3H_2O(l)$
E) $Fe(s) \rightarrow Fe^{2+}(aq) + 2e^-$

$\ln A_t - \ln A_0 = -kt$

$\ln A_t = -kt + \ln A_0$

$y \quad m \quad x$

Table 20.2

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

23) The standard cell potential ($E°_{cell}$) for the voltaic cell based on the reaction below is _____ V. 23) D

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

A) +0.46 B) -0.46 C) +1.39 D) +0.617 E) +1.21

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 <u>not</u> 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) Nuclei above the belt of stability can lower their neutron-to-proton ratio by _____. 25) B

A) gamma emission
B) beta emission
C) positron emission
D) electron capture
E) Any of the above processes will lower the neutron-to-proton ratio.

26) How many neutrons are emitted when a californium-249 nucleus (Z=98) is bombarded with a carbon-12 nucleus to produce a $^{257}_{104}Rf$ nucleus? 26) B

A) one B) four C) zero D) three E) two

27) ^{131}I has a half-life of 8.04 days. Assuming you start with a 1.53 mg sample of ^{131}I, how many mg will remain after 13.0 days? 27) D

A) 0.835 B) 0.268 C) 0.422 D) 0.499 E) 0.440

28) 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.) _____.? 28) D

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

29) Which one of the following ions <u>cannot</u> form both a high spin and a low spin octahedral complex ion? 29) A

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

30) Formation of a complex species of M^{n+} metal ion with ligands often _____. 30) 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) A complex that absorbs light at 700 nm will appear _____. 31) E

A) yellow B) violet C) red D) orange E) green

32) Which one of the following substances has three unpaired d electrons? 32) C

A) $[Ag(NH_3)_2]^+$
B) $[Zn(NH_3)_4]^{2+}$
C) $[Cr(CN)_6]^{3-}$
D) $[V(H_2O)_6]^{4+}$
E) $[Cu(NH_3)_4]^{2+}$

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

A) $[NiCl_4]^{2-}$
B) $[Pt(NH_3)_2Cl_2]$
C) $[Cr(NH_3)_6]^{3+}$
D) $[Fe(CN)_6]^{3}$
E) $[Co(H_2O)_6]^{2+}$

TRUE/FALSE. Circle 'A' if the statement is true and 'B' if the statement is false (3 pts each).

34) Under ordinary conditions, a substance will sublime rather than melt if its triple point occurs at a pressure above atmospheric pressure. 34) T

35) The solubility of slightly soluble salts containing basic anions is proportional to the pH of the solution. 35) F

36) Rates of reaction can be positive or negative. 36) F

37) Transition metal complexes are colored because of the energy gap between the d orbitals. 37) T

38) Positron emission causes a decrease of one in the atomic number. 38) T