You are writing VERSION 1 of this test. Make sure you have correctly entered your version number ("1") in the correct column on your scan sheet (see p. 2 for details).

Section #1 – These questions are worth two marks each.

____ 1. What is the **pH** of a 0.0242 M solution of HNO_3?

a. 4.214
b. 1.62 Part Mark
c. 2.11
d. 3.18
e. 1.616

Strong acid therefore it fully dissociates.

$[H_3O^+] = 0.0242$
$pH = -\log(0.0242)$
$pH = 1.616$

Note the sig. figs. with logs.

____ 2. Which of the following will create a **basic solution** in water?

i. MgF_2
ii. NH_4Cl
iii. LiBr
iv. NaCHOO
v. K_3PO_4

i. Yes! F^- is conjugate of weak acid (HF)
ii. No! NH_4^+ is conjugate of a weak base (NH_3)
iii. No! Both are conjugates of a strong acid & base
iv. Yes! $CHOO^-$ is the conjugate of weak acid (CHOOH)
v. Yes! PO_4^{3-} is the conjugate of a weak acid (HPO_4^{2-})

a. i, iv, v
b. ii, iii, iv
c. i, iv – Part Mark
d. ii, iv
e. iii

Continued on next page…

____ 3. Which of the following statements about the accompanying reaction is **correct**?

a.	$H_2O + SO_3 \rightarrow H_2SO_4$	H_2O is a Lewis acid
b.	$NH_4^+ + H_2O \rightarrow NH_3 + H_3O^+$	The solution will be alkaline
c.	$SnCl_4 + 2Cl^- \rightarrow [SnCl_6]^{2-}$	Cl^- is a Lewis base
d.	$OH^- + CO_2 \rightarrow HCO_3^-$	CO_2 is a Lewis base
e.	$CH_3NH_2 + H_2O \rightarrow CH_3NH_3^+ + OH^-$	H_2O is a Bronsted-Lowry base

a. False. H_2O is a Lewis base
b. False. H_3O^+ is produced. The solution is acidic
c. True
d. False. CO_2 accepts electrons from OH^- (Lewis acid)
e. False. Water donates a proton (B.L. acid)

____ 4. What is the **pH** of a 0.140M NaOCN solution? (K_a HOCN = 3.5 x 10^{-4})

a. 7.83
b. 8.30
c. 9.53
d. 12.70
e. 6.21

	OCN^-	+	H_2O	$\rightleftharpoons$	HOCN	+	OH^-
I	0.140		-----		0		0
C	-x		-----		+x		+x
E	0.140 – x		-----		x		x

Rule of 100 can simplify 0.140 – x to 0.140

$$2.9 \times 10^{-11} = \frac{x^2}{0.140}$$

$$x = 2.0 \times 10^{-6}$$

$$pOH = -\log(2.0 \times 10^{-6})$$

$$pOH = 5.69897$$

$$pH = 14 - 5.69897$$

$$pH = 8.30$$

____ 5. Which of the following acids has the **strongest conjugate base**?

a.	$H_2C_6H_5O_7^-$	K_a = 4.0 x 10^{-7}
b.	HOC_6H_5	K_a = 1.0 x 10^{-10}
c.	CH_3COOH	K_a = 1.8 x 10^{-5}
d.	HSO_4^-	K_a = 1.1 x 10^{-2}
e.	$(CH_3)_3NH^+$	K_a = 1.6 x 10^{-10}

The weaker the acid, the stronger the conjugate base, therefore, look for the acid with the lowest K_a

Continued on next page...

____ 6. What is the **percent ionization** of 0.250M ascorbic acid? (pK_a = 4.17)

a. 9.1%
b. 2.1%
c. 1.6%
d. 6.7%
e. 7.8%

	HAbs	+	H_2O	⇌	Abs^-	+	H_3O^+
I	0.250		-----		0		0
C	-x		-----		+x		+x
E	0.250 – x				x		x

$$6.761 \times 10^{-5} = \frac{x^2}{0.250}$$

$$x = 4.111 \times 10^{-3}$$

$$\frac{4.111 \times 10^{-3}}{0.250} \times 100$$

$$= 1.6\%$$

____ 7. Copper metal is currently $3.00 / lb, while zinc metal is $1.00 / lb. If you were given 1000 lb of CuO and unlimited, free sulfuric acid, **how much money could you make** by producing copper metal with zinc?

a. $ 1570
b. $ 3880
c. $ 3010
d. $ 1150
e. $ 789

$CuO(s) + H_2SO_4(aq) \rightarrow CuSO_4(aq) + H_2O(l)$
$CuSO_4(aq) + Zn(s) \rightarrow ZnSO_4(aq) + Cu(s)$

Note all 1:1 ratios
Molar mass of CuO = 79.545 g/mol
% comp of copper in CuO = 63.546 / 79.545 x 100 = 79.89%
Therefore in 1000 lb CuO, there are 798.87 lb Cu

Since it's a 1:1 mole ratio, you can use the ratio of the atomic masses to determine how much Zn you need.

$$798.87\left(\frac{65.39}{63.546}\right)$$

$$= 822.05 \text{ lb Zn}$$

Profit = (798.87 x 3)-(822.05 x 1)
Profit = $1570

Continued on next page…

____ 8. How many **neutrons** are contained in 2.0 g of Cl_2 (g)?

a. 4.3×10^{22}
b. 4.9×10^{24}
c. 1.8×10^{24}
d. 6.3×10^{23}
e. 9.5×10^{23}

$$2.0g\left(\frac{1molCl_2}{70.906g}\right)\left(\frac{6.022\times10^{23}Cl_2}{1molCl_2}\right)\left(\frac{2\text{ Cl atoms}}{1Cl_2}\right)\left(\frac{18.453neutrons}{1\text{ Cl atom}}\right)$$
$$=6.3x10^{23}\text{ neutrons}$$

____ 9. Hydrogen (4.0 g) and oxygen (32 g) are reacted to give water (18 g). What is the **percent yield** of this reaction?

a. 100 %
b. 90 %
c. 75 %
d. 40 %
e. 50 %

$$4.0g\left(\frac{1mol}{2.0258g}\right)\left(\frac{2molH_2O}{2molH_2}\right)\left(\frac{18.0148g}{1mol}\right)$$
$$=35.57gH_2O$$

$$\frac{18g}{35.57g}\times100$$
$$=50\%$$

____ 10. Determine the **false** statement:

a. Lithium has a half filled sub-shell
b. In the outer most shell, Be and He have different number of electrons
c. Helium and magnesium both have valence electrons with quantum numbers l = 0, m_l = 0 and, m_s = +1/2 & -1/2
d. The 6s orbital is filled before the 5d
e. Silicon has unfilled d orbitals

a. TRUE
b. False – in the outermost shell, both Be and He have 2 electrons
c. TRUE
d. TRUE
e. TRUE

Continued on next page…

____11. Calculate the **frequency of light** emitted when the electron in a hydrogen atom moves from n = 7 to n = 2.

a. 2.89×10^{13}
b. 3.44×10^{14}
c. 4.21×10^{15}
d. 9.01×10^{12}
e. 7.55×10^{14}

$$E = -R_H\left(\frac{1}{n_i^{\,2}} - \frac{1}{n_f^{\,2}}\right)$$

$$E = -5.0028 \times 10^{-19} J \text{ (emitted)}$$

$$E = h\nu$$

$$\nu = 7.55 \times 10^{14}$$

____12. Which of the following elements would expect to have the **lowest boiling point?**

a. Mg
b. P_4
c. Na
d. S_8
e. Kr

All of the compounds except for Kr are solids at room temp. Kr is a noble gas, therefore it has the lowest boiling point.

____13. Consider the following reaction in the **gas phase**. Which combination of M and E will require the **least amount of energy**?

$$M(g) + E(g) \rightarrow M^+E^-(g)$$

a. M = Rb; E = F
b. M = K; E = I
c. M = Mg; E = O
d. M = Ca; E = S
e. M = Al; E = Cl

You need electrons to be easily lost and gained for the reaction to require the least amount of energy. Therefore look for those atoms with the highest electron affinity and lowest ionization energy.

Continued on next page...

____ 14. Determine the **correct** statement:

a. A coordinate covalent bond occurs in NH_3
b. The bond is KCl would be considered polar covalent
c. SF_4 has a dipole moment
d. The average P-Cl bond order in PCl_3 is 4/3
e. The nitrate anion has no resonance structures

a. False. In NH_3 there are only covalent bonds, in NH_4^+ there is a coordinate covalent bond between the 4th hydrogen and nitrogen
b. False. KCl would be ionic (metal and non-metal)
c. True. Shape is see-saw, therefore non-symmetrical
d. False. PCl_3 is trigonal pyramidal and only has single bonds, therefore the Bond Order = 1
e. False. There are two single N-O bonds and one double N=O bond, therefore there are resonance structures possible.

____ 15. **Rank** the following solutions from **weakest to strongest** (LEFT → RIGHT) **electrolyte** that can conduct electricity:

i. KI (aq, 1 M)
ii. Na_2SO_4 (aq, 1M)
iii. CH_3OH (l)
iv. $Ba(OH)_2$ (aq, 1 g)

i. Fully soluble, 1 cation, 1 anion produced
ii. Fully soluble, 2 cations, 1 anion produced
iii. Polar liquid
iv. Sparingly soluble and less than one mole of substance

a. i, iii, iv, ii
b. ii, iv, i, iii
c. iv, ii, iii, i
d. iii, iv, i, ii
e. iv, ii, i, iii

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____ 16. **Select** the correct answer that **best describes the mechanism** that explains why people drinking ground water supply that are composed of **insoluble** calcium fluoride and calcium carbonate mineral deposits tend to have **lower incidents of skeletal fluorosis** than other water sources containing **only** calcium fluoride:

a. Pulverized charred animal bone is used as an ion-exchange material for water filtration

b. Hydroxyapatite is formed with dissolution of calcium carbonate to trap dissolved fluoride

c. Skeletal fluorosis is a beneficial health effect with high level exposure to fluoride that increases bone strength

d. The acidification of water by dissolution of calcium carbonate increases the molar solubility of calcium fluoride

e. The molar solubility of calcium fluoride is decreased due to the common ion effect

If they are drinking water with both calcium fluoride and calcium carbonate present, then the calcium ions from $CaCO_3$ will lower the molar solubility of CaF_2 because of the common ion effect.

A. True but irrelevant to the question
B. False. Calcium cation and carbonate anion is formed form the dissolution of calcium carbonate
C. False
D. Carbonate ion will make the water more alkaline, not more acidic
E. TRUE

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____17. Given the solubility product equilibrium constants below, predict the **order of preciptation** (FIRST → LAST) of an **equimolar mixture of four heavy metal ions** in aqueous solution upon addition of increasing amounts of **Na_2S (aq):**

i. K_{sp} for PbS is 3.0×10^{-28}
ii. K_{sp} for SnS is 1.0×10^{-26}
iii. K_{sp} for HgS is 2.0×10^{-53}
iv. K_{sp} for CdS is 8.0×10^{-28}

a. iii, ii, iv, i
b. ii, iv, i, iii
c. iv, i, ii, iii
d. iii, iv, i, ii
e. i, iv, iii, iv

Order Ksp from lowest to highest.
NOTE: This question did not have a correct answer. ALL students will receive 2 marks for this question.

____18. Correctly identify the **oxidizing agent, its oxidation state/number and its stoichiometry** in the following **unbalanced** redox reaction used for removal of dissolved molecular oxygen from boilers that is useful for the prevention of metal corrosion. **Note:** This reaction takes place in acidic conditions.

$$O_2\,(aq) + N_2H_4\,(aq) \rightarrow N_2\,(g)$$

	Oxidizing agent	Oxidation state	Stoichiometric factor
a.	O_2	-4	2
b.	N_2H_4	+2	1
c.	N_2	0	1
d.	N_2H_4	-2	2
e.	O_2	0	1

Oxidation numbers for nitrogen and hydrogen on N_2H_4 = -2, +1
Nitrogen gas has an oxidation number of 0, therefore nitrogen has been oxidized.

Since nitrogen is oxidized, then oxygen MUST be reduced, and it is therefore an oxidizing agent (eliminates answers B – D). Oxygen gas has an oxidation number of 0, therefore E is the right answer.

No need to balance the equation.

Continued on next page…

____ 19. Determine the effective **concentration of fluoride (mM)** in solution containing the insoluble calcium fluoride (CaF_2) if its K_{sp} at 25°C is 5.3 x 10^{-9}:

a. 1.1 – Part Mark
b. 0.14
c. 12
d. 2.2
e. 0.55

	CaF_2	⇌	Ca^{2+}	+	$2F^-$
I	-----		0		0
C	-----		+x		+2x
E	-----		x		2x

$$5.3 \times 10^{-9} = (x)(2x)^2$$

$$x = 1.09 \times 10^{-3} M$$

$$2x = F^-$$

$$[F^-] = 2.2$$

Continued on next page…

____20. Identify which reaction(s) will **NOT** generate a **precipitate**?

i. $ZnCl_2$ (aq) + $(NH_4)_2SO_4$ (aq) →
ii. NaOH (aq) + $MgCl_2$ (aq) →
iii. $CaCl_2$ (aq) + Na_3PO_4 (aq) + NaOH (aq) →
iv. NaOH (aq) + $PbNO_3$ (aq) →
v. NaI (aq) + KNO_3 (aq) →

i. $ZnSO_4$ and NH_4Cl are both soluble
ii. $Mg(OH)_2$ is a solid
iii. Ca_3PO_4 is a solid
iv. $Pb(OH)_2$ is a solid
v. $NaNO_3$ and KI are both soluble

a. ii, iii, iv
b. ii, v
c. i, v
d. iii
e. i, iv

____21. Which of the following represent **correct equilibrium constant expressions** for the given reaction:

a. $Cu(NH_3)_4^{2-}$ (aq) ⇌ Cu^{2+}(aq) + $4NH_3$(aq) $K_c = \frac{[Cu^{2+}][4NH_3]^4}{[Cu^{2+}(NH_3)_4^{2+}]}$

b. CO_2(g) + C(s) ⇌ 2CO(g) $K_P = \frac{(P_{CO})^2}{P_{CO_2} \bullet P_C}$

c. $2NaHCO_3$(s) ⇌ Na_2CO_3(s) + CO_2(g) + H_2O(g) $K_p = P_{CO_2} \bullet P_{H_2O}$

d. PCl_5(g) ⇌ PCl_3(g) +Cl_2(g) $K_P = \frac{P_{Cl_3}}{P_{Cl_5} \bullet P_{Cl_2}}$

e. CH_3COOH (aq) + H_2O(l) ⇌ CH_3COO^- (aq)+ H_3O^+(aq) $K_c = \frac{[CH_3COO^-][H_3O^+]}{[CH_3COOH][H_2O]}$

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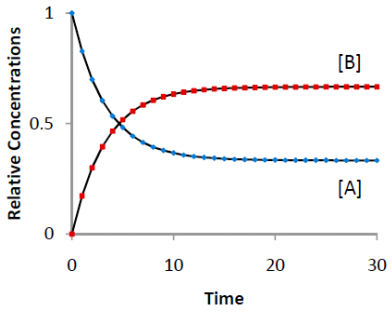
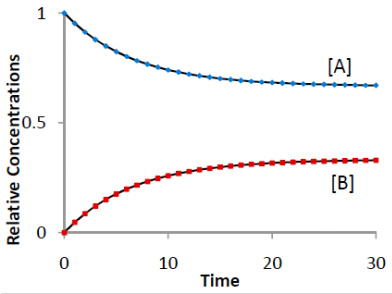
____22. For the general reaction, A (aq) ⇌ B(aq)

Which of the following graphs **represent an equilibrium** whose K is >>1?

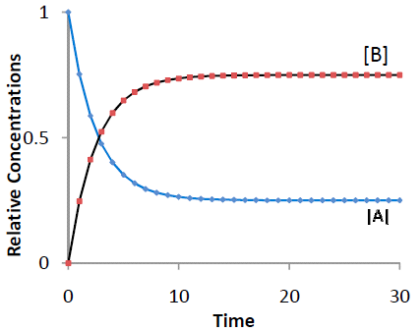
a.



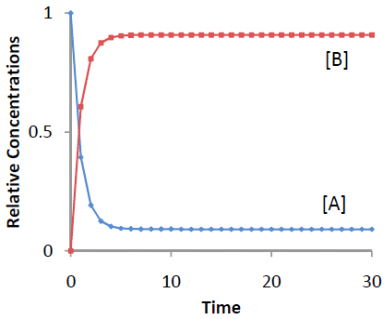
b.



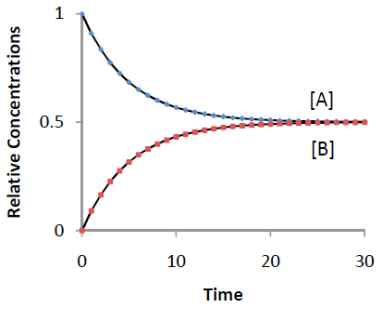
c.



d.



e.



If K >>1 then there needs to be a lot of product and very little reactant left at equilibrium. While A, C and D look similar, D has the greatest difference between starting and final concentrations of both products and reactants.

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____23. Choose the **one false** statement from the following list.

a. K_{ow} represents the degree to which a given solute prefers to dissolve in an organic solvent, such as 1-octanol, and is a measure of the lipophilicity of the molecule. S(aq) $\rightleftharpoons$ S(org)

b. In the Haber Bosch process, the high temperature is counterproductive, based on the chemistry of the overall reaction, but necessary increase the reaction rate. $3H_2(g) + N_2(g) \rightleftharpoons 2NH_3(g)$ $\Delta H = -46.1\ kJ/mol$

c. Caffeine extraction requires continuous refreshment of the organic phase to achieve the target decaffination level of the beans in the aqueous phase, because the K_{ow} of the caffeine molecule is so large.

d. Overuse of nitrogen-based fertilizers influences the equilibria that include nitrogen species in the biosphere, and has resulted in major environmental impacts in water bodies and wildelife populations.

e. Persistent Organic Pollutants (POPs), such as DDT, are resistant to breakdown through natural biochemical pathways, resulting in their bioaccumulation and long-term health risks.

a. True
b. True
c. False. K_{ow} of caffeine is small, therefore it doesn't readily dissolve in the organic phase.
d. True
e. True

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____24. Hydrogen fluoride is a highly reactive gas. It has many industrial uses, but the most familiar property of HF is its ability to react with glass. As a result, HF is used to etch glass, and frost the inner surfaces of light bulbs. Hydrogen fluoride may be produced from H_2 and F_2:

$$H_2(g) + F_2(g) \rightleftharpoons 2HF(g) \qquad Kp = 115$$

In a particular experiment, 3.00 atm of each of $H_2(g)$ and $F_2(g)$ are placed in a 1.50-L flask. Calculate the **equilibrium partial pressures** of the product, HF.

a. 5.06 atm

b. 8.78 atm

c. 1.64 atm

d. 2.31 atm

e. 3.72 atm

	$H_2(g)$	+	$F_2(g)$	$\rightleftharpoons$	2HF(g)
I	3		3		0
C	-x		-x		+2x
E	3-x		3-x		2x

$$115 = \frac{(2x)^2}{(3-x)^2}$$

$$\sqrt{115} = \sqrt{\frac{(2x)^2}{(3-x)^2}}$$

$$10.724 = \frac{2x}{3-x}$$

$$x = 2.5285$$

$$\text{Pressure HF} = 5.06\text{atm}$$

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____25. For the reversible transformation between butane and isobutane (2-methylpropane), represented below, K = 2.50 at 298 K – although net reaction to attain equilibrium is extremely slow.

Butane  Isobutane

Is a reaction mixture at 298 K at equilibrium if [butane] = 0.97 M and [isobutane] = 2.18 M? **If not, in which direction would the reaction need to proceed** to achieve equilibrium?

a. Under these conditions, $Q_c > K_c$, the reaction proceeds in the reverse direction

b. Under these conditions, $Q_c < K_c$, the reaction proceeds in the reverse direction

c. Under these conditions, $Q_c < K_c$, the reaction proceeds in the forward direction

d. Under these conditions, $Q_c = K_c$, the reaction is at equilibrium

e. Under these conditions, $Q_c > K_c$, the reaction proceeds in the forward direction

Q=[isobutene]/[butane]
Q=2.247

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Section #2 – These questions are worth three marks each.

____26. In a reaction mixture at a certain temperature, butane and isobutane are in chemical equilibrium when [butane] = 0.20 mol L^{-1} and [isobutane] = 0.50 mol L^{-1}. Enough isobutane is added to the mixture to increase its concentration by 2.00 mol L^{-1}. What are the concentrations of butane and isobutane after equilibrium is re-established?

Butane ⇌ Isobutane K = 2.50

a. [butane] = 0.2 M [isobutane] = 2.6 M

b. [butane] = 0.7 M [isobutane] = 2.3 M

c. [butane] = 0.5 M [isobutane] = 1.0 M

d. [butane] = 0.8 M [isobutane] = 1.9 M

e. [butane] = 1.0 M [isobutane] = 1.8 M

	Butane	⇌	Isobutane
I	0.20		2.50
C	+x		-x
E	0.20+x		2.50-x

$$2.50 = \frac{2.50 - x}{0.20 + x}$$

$$x = 0.5714$$

[Butane] = 0.20 + 0.5714
[Butane] = 0.77 M

[Isobutane] = 2.50 - x
[Isobutane] = 1.928 M

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____27. What **mass of ammonium sulphate** must be added to 350.0 mL of water to create a solution with a pH of 4.70? (K_b NH_3 = 1.8 x 10^{-5})

a. 3.1 x 10^1 g
b. 6.5 g
c. 5.1 x 10^1 g
d. 9.4 g
e. 1.7 x 10^1 g

If pH = 4.70, then $[H_3O^+]$ = 1.9953 x 10^{-5}

	NH_4^+	+	H_2O	⇌	NH_3	+	H_3O^+
I	Y		-----		0		0
C	-x		-----		+x		+x
E	y-x		-----		x		x

$$5.56\times10^{-10} = \frac{x^2}{y-x}$$

But, x = 1.9953×10^{-5}

$$5.56\times10^{-10} = \frac{(1.9953\times10^{-5})^2}{y-1.9953\times10^{-5}}$$

$$y = 0.71607M$$

$$0.350L\left(\frac{0.71607mol}{1L}\right)\left(\frac{1mol\ (NH_4)_2SO_4}{2mol(NH_4^+)}\right)\left(\frac{132.1392g}{1mol}\right)$$

$$= 16.57g$$

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____28. Toxic levels of chromate (CrO_4^{2-}) in water can be removed by reacting it with excess thiolate ($S_2O_4^{2-}$) to generate insoluble $Cr(OH)_3$ as a precipitate that can be filtered. Balance the following redox reaction under **alkaline conditions** and assign the correct **stoichiometry** for **CrO_4^{2-} (aq) and SO_3^{2-} (aq)**:

$$CrO_4^{2-}\ (aq) + S_2O_4^{2-}\ (aq) \rightarrow Cr(OH)_3\ (s) + SO_3^{2-}\ (aq)$$

a. 1 CrO_4^{2-}, 3 SO_3^{2-}
b. 2 CrO_4^{2-}, 6 SO_3^{2-}
c. 3 CrO_4^{2-}, 5 SO_3^{2-}
d. 2 CrO_4^{2-}, 1 SO_3^{2-}
e. 5 CrO_4^{2-}, 2 SO_3^{2-}

½ Reactions:

$3e^- + 4H_2O + CrO_4^{2-} \rightarrow Cr(OH)_3 + 5OH^-$

$4OH^- + S_2O_4^{2-} \rightarrow 2SO_3^{2-} + 2H_2O + 2e^-$

Overall:

$2H_2O + 2CrO_4^{2-} + 2OH^- + 3S_2O_4^{2-} \rightarrow 2Cr(OH)_3 + 6SO_3^{2-}$

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____29. What is the value of the **reaction quotient (*Q*)** if 20 mL of a 0.15 M solution of $Al(NO_3)_3$ (aq) is mixed with 5.0 mL of a 0.40 M solution of NaOH (aq). Also, **identify the precipitate** and predict whether the precipitate will be formed given that its K_{sp} at 25°C is 1.3×10^{-33}

a. Yes, $Al(OH)_3$ precipitate will be formed since $Q = 6.1 \times 10^{-5}$

b. No, $Al(OH)_3$ precipitate will not be formed since $Q = 6.1 \times 10^{-5}$

c. No precipitate will be formed in this reaction as all salts are soluble

d. Yes, $NaNO_3$ precipitate will be formed since $Q = 3.5 \times 10^{-14}$

e. No, $NaNO_3$ precipitate will not be formed since $Q = 3.5 \times 10^{-14}$

$Al(NO_3)_3\ (aq) + 3NaOH(aq) \rightarrow 3NaNO_3(aq) + Al(OH)_3(s)$

$Al(OH)_3\ (s) \rightleftharpoons Al^{3+}(aq) + 3OH^-(aq)$

$[Al^{3+}] = (0.020L \times 0.15\ M)/0.025$
$= 0.12M$

$[OH^-] = (0.005 \times 0.40M)/0.025$
$= 0.08M$

$Q = [Al^{3+}]\ [OH^-]^3$
$Q = 6.1 \times 10^{-5}$
$Q > Ksp$, therefore a precipitate forms.

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____30. Which of the following molecules have the **same molecular shape?**

a. $GaCl_4^-$ & PCl_4^+
b. BH_3 & SH_3^+
c. BrF_4^+ & SiF_4
d. NH_3 & CH_3^+
e. PCl_2^+ & $AlCl_2^+$

a. Both tetrahedral
b. BH_3 is trigonal planar, while SH_3^+ is trigonal pyramidal
c. BrF_4^+ is see saw, while SiF_4 is tetrahedral
d. NH_3 is trigonal pyramidal, while CH_3^+ is trigonal planar
e. PCl_2^+ is bent while $AlCl_2^+$ is linear

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ROUGH WORK

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Some general data are provided on this page and the next page. Other data appear with the questions.

A periodic table is provided on the next page.

STP = 273.15 K, 1 atm F = 96485 C/mol

R = 8.3145 J/K · mol = 0.08206 L · atm/K · mol NA = 6.022×10^{23} mol^{-1}

1 atm = 760 mm Hg = 101.325 kPa 0°C = 273.15 K

1 J = 1 kg m^2 s^{-2} = 1 kPa·L = 1 Pa·m^3 1 m = 10^9 nm = 10^{10} Å

1 cm^3 = 1 mL 1 g = 10^3 mg = 10^{-3} kg

1 Hz = 1 cycle/s c = 2.9979×10^8 m/s

h = 6.6256×10^{-34} J · s m_e = 9.10×10^{-31} kg

λ = h / mu = h / p

En = $-R_H / n^2 = -2.179 \times 10^{-18}$J / n^2 (R_H is the energy form of the Rydberg constant for H)

K_w = 1.0×10^{-14} (25 °C) K.E. = ½ mu^2

TABLE 5.1 Solubility 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 (with some exceptions for Li^+) and the NH_4^+ cation are soluble.
2. Nitrates, acetates, and perchlorates are soluble.
3. Salts of silver, lead, and mercury(I) are insoluble.
4. Chlorides, bromides, and iodides are soluble.
5. Carbonates, phosphates, sulfides, oxides, and hydroxides are insoluble (sulfides of group 2 cations and hydroxides of Ca^{2+}, Sr^{2+}, and Ba^{2+} are slightly soluble).
6. Sulfates are soluble except for those of calcium, strontium, and barium.

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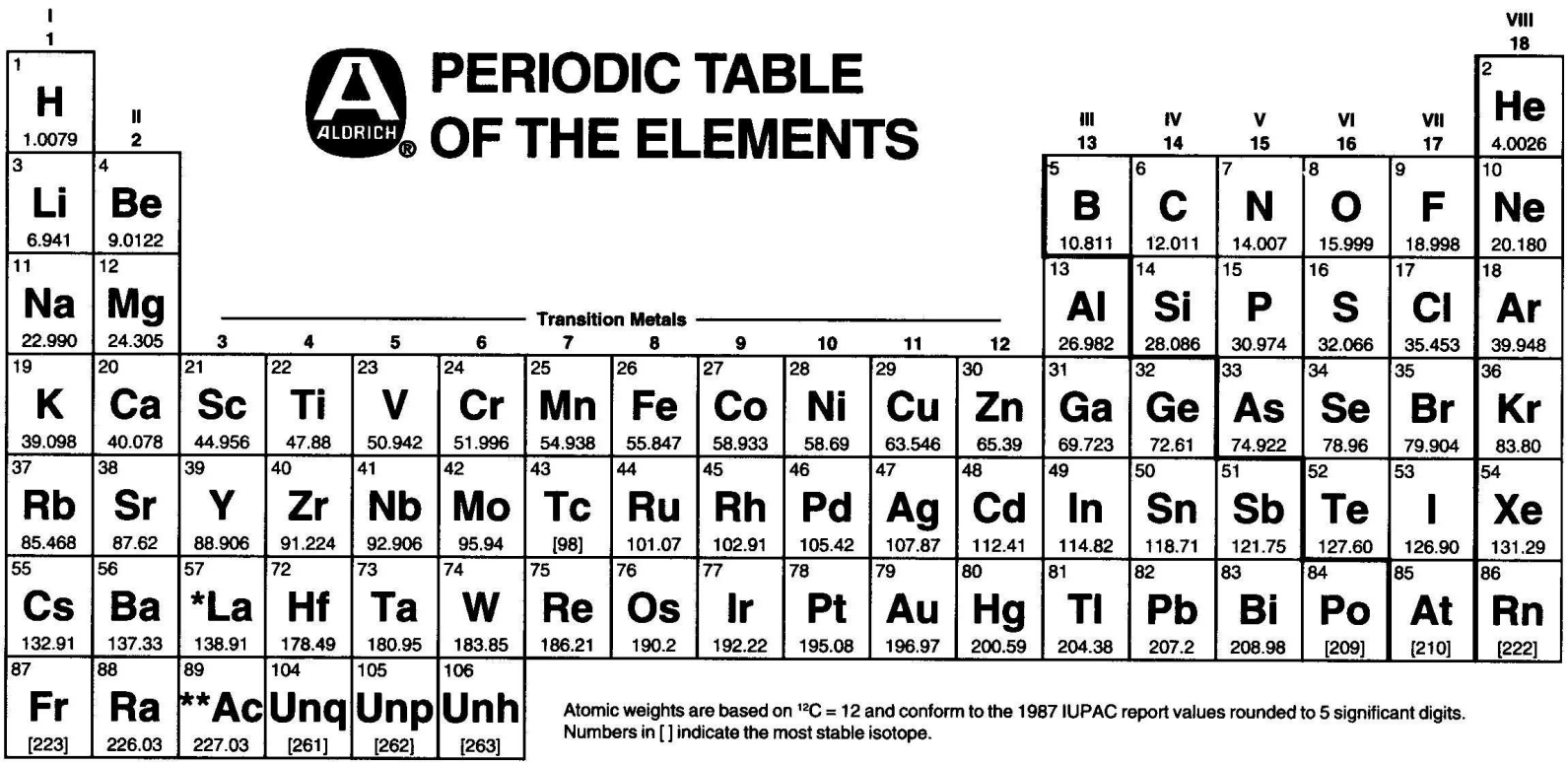
PERIODIC TABLE OF THE ELEMENTS
ALDRICH
Transition Metals
I 1 II 2 3 4 5 6 7 8 9 10 11 12 III 13 IV 14 V 15 VI 16 VII 17 VIII 18
1 H 1.0079
2 He 4.0026
3 Li 6.941
4 Be 9.0122
5 B 10.811
6 C 12.011
7 N 14.007
8 O 15.999
9 F 18.998
10 Ne 20.180
11 Na 22.990
12 Mg 24.305
13 Al 26.982
14 Si 28.086
15 P 30.974
16 S 32.066
17 Cl 35.453
18 Ar 39.948
19 K 39.098
20 Ca 40.078
21 Sc 44.956
22 Ti 47.88
23 V 50.942
24 Cr 51.996
25 Mn 54.938
26 Fe 55.847
27 Co 58.933
28 Ni 58.69
29 Cu 63.546
30 Zn 65.39
31 Ga 69.723
32 Ge 72.61
33 As 74.922
34 Se 78.96
35 Br 79.904
36 Kr 83.80
37 Rb 85.468
38 Sr 87.62
39 Y 88.906
40 Zr 91.224
41 Nb 92.906
42 Mo 95.94
43 Tc [98]
44 Ru 101.07
45 Rh 102.91
46 Pd 105.42
47 Ag 107.87
48 Cd 112.41
49 In 114.82
50 Sn 118.71
51 Sb 121.75
52 Te 127.60
53 I 126.90
54 Xe 131.29
55 Cs 132.91
56 Ba 137.33
57 *La 138.91
72 Hf 178.49
73 Ta 180.95
74 W 183.85
75 Re 186.21
76 Os 190.2
77 Ir 192.22
78 Pt 195.08
79 Au 196.97
80 Hg 200.59
81 Tl 204.38
82 Pb 207.2
83 Bi 208.98
84 Po [209]
85 At [210]
86 Rn [222]
87 Fr [223]
88 Ra 226.03
89 **Ac 227.03
104 Unq [261]
105 Unp [262]
106 Unh [263]
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.
* Lanthanides
58 Ce 140.12
59 Pr 140.91
60 Nd 144.24
61 Pm [145]
62 Sm 150.36
63 Eu 151.97
64 Gd 157.25
65 Tb 158.93
66 Dy 162.50
67 Ho 164.93
68 Er 167.26
69 Tm 168.93
70 Yb 173.04
71 Lu 174.97
** Actinides
90 Th 232.04
91 Pa 231.04
92 U 238.03
93 Np 237.05
94 Pu [244]
95 Am [243]
96 Cm [247]
97 Bk [247]
98 Cf [251]
99 Es [252]
100 Fm [257]
101 Md [258]
102 No [259]
103 Lr [262]