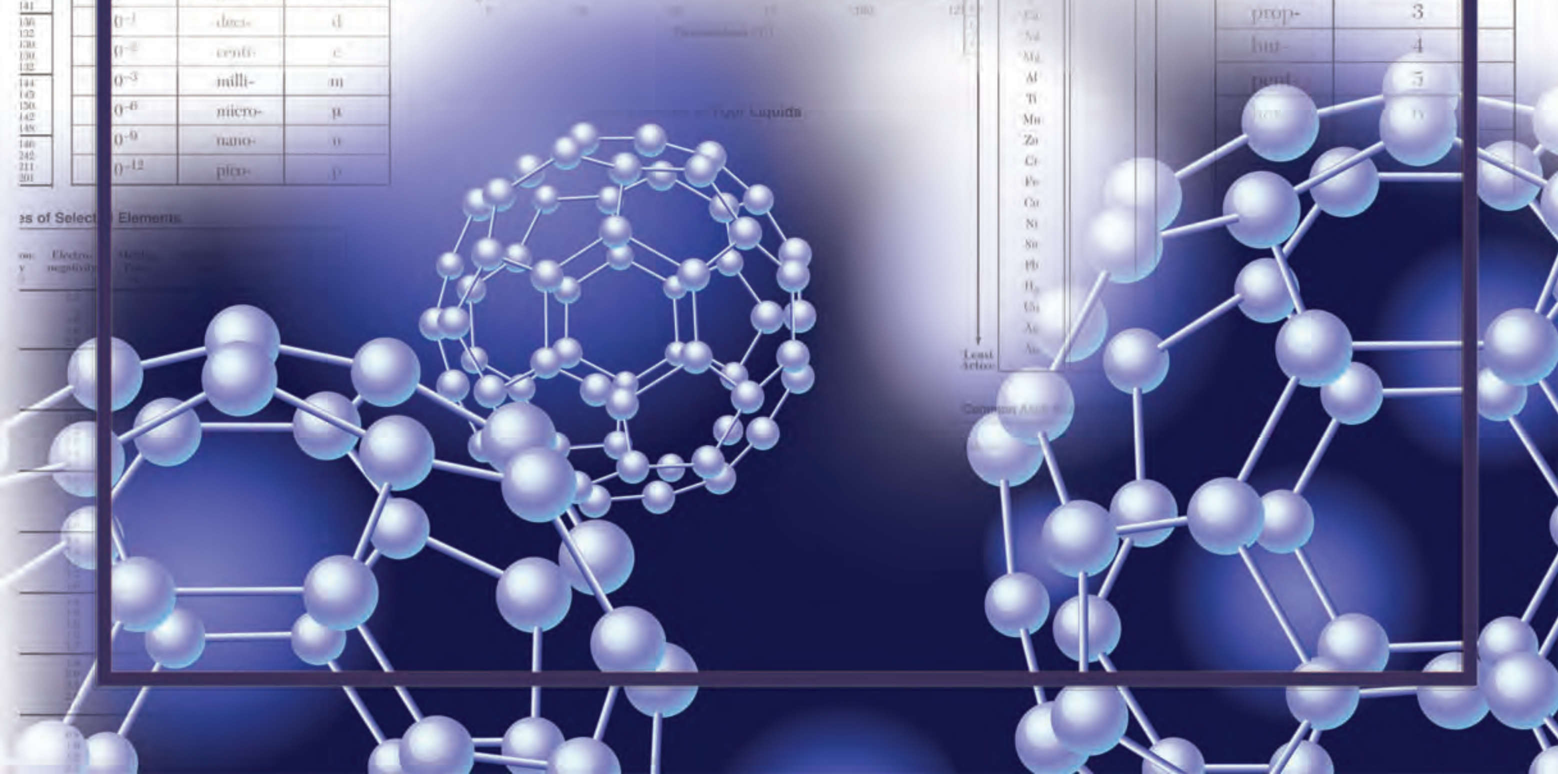
BONDING WITH THE REFERENCE TABLES

A Clear & Simple Chemistry Regents Guide

200+ actual Regents questions included

Y. Finkel



BONDING

WITH THE REFERENCE TABLES

A Clear & Simple
Chemistry Regents Guide

Y. Finkel

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What is This Book & How Do I Use It?

> This is a test of your knowledge of chemistry. Use that knowledge to answer all questions in this examination. Some questions may require the use of the *2011 Edition Reference Tables for Physical Setting/Chemistry*. You are to answer *all* questions in all parts of this examination according to the directions provided in this examination booklet.

Did you know that an average of about 34 questions in every Chemistry Regents (or about 40% of the regents) are partially or entirely based on the Chemistry Reference Tables?

If you know how to read *every* table on the Chemistry Reference Tables, that's terrific.

But what if you don't?

Gaining a clear understanding of the reference tables is crucial for the Chemistry Regents.

The good news is that one of the best-kept secrets of the chemistry regents is that the reference tables-based questions are the *easiest part of the regents by far* – **if you know how to use the reference tables.**

That's where this book comes in. ***Bonding with the Reference Tables: A Clear & Simple Chemistry Regents Guide*** is a book that:

- Gives step-by-step instructions in **clear** and **simple** terms on how to easily decipher each one of the 21 charts on the Chemistry Reference Tables

AND…

- Provides **actual regents questions** at the end of each section, along with answers and brief explanations at the end of the book

To Get the Most Out of This Book:

Read the book aloud with a friend so you don’t miss anything important.

As you read through the book, follow along with a separate copy of the Chemistry Reference Tables. This way, you won’t have to keep flipping pages from the tables to their explanations.

If you are pressed for time, start with the tables that appear most often on the regents. On each table, notice this icon  with a number. This represents the average number of questions on that table per regents.

For example, on the **Table F: Solubility Guidelines** chart, you see 

. This means that there is approximately 1 question on this table per regents.

After you finish reading about each table, do the **practice regents questions** on the table to ensure you understood it correctly. The practice questions are conveniently included after each section, symbolized by this icon: 

Note: Some regents questions have been edited slightly.

In addition, the “More Practice” section at the end of the book organizes all the reference tables-based regents questions from the January 2015-January 2020 regents by table.

These extra questions will provide you with even more opportunity to exercise the Reference Tables skills you have learned from this guide. This way, you will be fully prepared to tackle those questions on your upcoming regents exam.

Good luck!

Y. Finkel

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New York State Chemistry Reference Tables

Table E

Selected Polyatomic Ions

Table E
Selected Polyatomic Ions

Formula	Name	Formula	Name
H_3O^+	hydronium	CrO_4^{2-}	chromate
Hg_2^{2+}	mercury(I)	$Cr_2O_7^{2-}$	dichromate
NH_4^+	ammonium	MnO_4^-	permanganate
$C_2H_3O_2^-$ / CH_3COO^-	acetate	NO_2^-	nitrite
		NO_3^-	nitrate
CN^-	cyanide	O_2^{2-}	peroxide
CO_3^{2-}	carbonate	OH^-	hydroxide
HCO_3^-	hydrogen carbonate	PO_4^{3-}	phosphate
$C_2O_4^{2-}$	oxalate	SCN^-	thiocyanate
ClO^-	hypochlorite	SO_3^{2-}	sulfite
ClO_2^-	chlorite	SO_4^{2-}	sulfate
ClO_3^-	chlorate	HSO_4^-	hydrogen sulfate
ClO_4^-	perchlorate	$S_2O_3^{2-}$	thiosulfate

TABLE E: Selected Polyatomic Ions

Table E
Selected Polyatomic Ions

Formula	Name	Formula	Name
H_3O^+	hydronium	CrO_4^{2-}	chromate
Hg_2^{2+}	mercury(I)	$Cr_2O_7^{2-}$	dichromate
NH_4^+	ammonium	MnO_4^-	permanganate
$C_2H_3O_2^-$ / CH_3COO^-	acetate	NO_2^-	nitrite
		NO_3^-	nitrate
CN^-	cyanide	O_2^{2-}	peroxide
CO_3^{2-}	carbonate	OH^-	hydroxide
HCO_3^-	hydrogen carbonate	PO_4^{3-}	phosphate
		SCN^-	thiocyanate
$C_2O_4^{2-}$	oxalate	SO_3^{2-}	sulfite
ClO^-	hypochlorite	SO_4^{2-}	sulfate
ClO_2^-	chlorite	HSO_4^-	hydrogen sulfate
ClO_3^-	chlorate	$S_2O_3^{2-}$	thiosulfate
ClO_4^-	perchlorate		

Table E contains the names and formulas of 25 different **polyatomic ions**.

Polyatomic ion → several atoms covalently bonded resulting in a **charged particle** – an **ion**. Compounds with polyatomic ions within their structures are both **ionically** and **covalently** bonded.

Covalent bond → a relatively weak chemical bond created when an atom **shares** its valence electrons with another atom (or atoms)

Ionic bond → a stronger chemical bond created when valence electrons are **transferred** from one atom to another.

Table E is helpful…

- ➔ For **identifying** polyatomic ions *within formulas*
- ➔ When **writing formulas** of compounds containing polyatomic ions

Reading the Table:

- The **FORMULA** column tells you which elements make up each polyatomic ion, using the element's symbol, and how many of that element using subscripts.
  - ➔ Notice the **charge** in the upper right corner of each polyatomic ion. The charge is not just for the last element of the polyatomic ion – it is the *entire polyatomic ion* that is charged. It is this charge that gives it its ionic status and enable it to bond with other (regular) ions. (See below for further explanation.)
  - ➔ A charge of "+" or "-" without a number is understood to be "+**1**" or "-**1**."
- The **NAME** column gives you the chemical name of each polyatomic ion listed. Notice that many polyatomic ions end in "**–ate**."
- <u>Common Regents Questions on Table E:</u>
  - ➔ Often, you are asked to identify the polyatomic ion within a formula or a group of formulas. To answer these kinds of questions, simply look through Table E. If part of the formula is on Table E, that part is a polyatomic ion.

⇨ Ex1: Within the formula of potassium phosphate (K_3PO_4), the phosphate – PO_4 is the polyatomic ion.

⇨ Ex2: Within the formula of magnesium chlorate: $Mg(ClO_3)_2$, the chlorate – ClO_3 is the polyatomic ion. (The subscript 2 outside the parenthesis in magnesium chlorate's formula tells you that there are 2 chlorates present.)

➔ If you are given a compound containing a polyatomic ion (any formula on Table E), such as Na_2**CO_3** (containing the polyatomic ion **carbonate**) and asked which two types of chemical bonding are contained within this compound, the answer will always be **"ionic and covalent."** (This is because while the atoms that make up a polyatomic ion are covalently bonded – the elements are sharing valence electrons with each other, the polyatomic ion has a charge, which attracts and attaches to another ion of an opposite charge. This is ionic bonding.)

⇨ The same is true vice versa. If asked to choose the compound that contains more than one kind of chemical bonding, look for a **polyatomic ion** from Table E.

➔ If asked where the ionic bond is in a compound containing a polyatomic ion, such as K_3**PO_4**, it is between the *entire polyatomic ion* (PO_4) and the *other element* in the compound (K). Do not split up the ion and choose K_3P and O_4 as your answer, since the entire PO_4 makes up the ion.

➔ To ***write the formula*** of a compound containing a polyatomic ion, follow the regular steps (discussed under **oxidation states** in the PT), but treat the entire ion as a single unit, with the charge belonging to the whole thing.

⇨ Example 1: What is the chemical formula for ***ammonium*** *sulfide*?

✓ Write out the symbols of each element/polyatomic ion with their oxidation states (charges): **$(NH_4)^+S^{2-}$**

✓ "Crisscross" each charge, changing it to a subscript of the other element. Omit the charges: **$(NH_4)_2S_1$** - notice the charge from the S became a subscript of the entire NH_4, indicated by the parenthesis around the ion.

✓ If one subscript is a factor of another, simplify. If any of the subscripts is a 1, leave it out: **$(NH_4)_2S$**

⇨ Example 2: What is the chemical formula for *magnesium* ***nitrate***?

✓ Write out the symbols with their oxidation states: **$Mg^{2+}(NO_3)^-$**

✓ "Crisscross" each charge, changing it to a subscript. Omit the charges: **$Mg_1(NO_3)_2$**

✓ Simplify: **$Mg(NO_3)_2$**

1. Which polyatomic ion is found in the compound represented by the formula $NaHCO_3$?
   (1) hydrogen sulfate
   (2) hydrogen carbonate
   (3) Acetate
   (4) oxalate

2. Which polyatomic ion has a charge of 3-?
   (1) chromate
   (2) oxalate
   (3) phosphate
   (4) thiocyanate

3. What is the name of the polyatomic ion in the compound Na_2O_2?
   (1) Hydroxide
   (2) Oxalate
   (3) oxide
   (4) peroxide

4. What is the chemical formula for ammonium sulfide?
   (1) $(NH_4)_2S$
   (2) $(NH_4)_2SO_3$
   (3) $(NH_4)_2SO_4$
   (4) $(NH_4)_2S_2O_3$

5. What is the chemical formula for sodium sulfate?
   (1) Na_2SO_4
   (2) Na_2SO_3
   (3) $NaSO_4$
   (4) $NaSO_3$

6. What is the chemical formula for zinc carbonate?
   (1) $ZnCO_3$
   (2) $Zn(CO_3)_2$
   (3) Zn_2CO_3
   (4) Zn_3CO

7. In the compound $KHSO_4$, there is an ionic bond between the
   (1) KH^+ and SO_4^{2-} ions
   (2) $KHSO_3^-$ and O^{2-} ions
   (3) K^+ and HS^- ions
   (4) K^+ and HSO_4^- ions

8. Magnesium nitrate contains chemical bonds that are
   (1) covalent, only
   (2) ionic, only
   (3) both covalent and ionic
   (4) neither covalent nor ionic

9. Which compound contains both ionic and covalent bonds?
   (1) Ammonia
   (2) sodium nitrate
   (3) methane
   (4) potassium chloride

10. *Thermal energy is absorbed as chemical reactions occur during the process of baking muffins. The batter for muffins often contains baking soda, $NaHCO_3(s)$, which decomposes as the muffins are baked in an oven at 200.°C…*
    $2NaHCO_3(s) + heat \rightarrow Na_2CO_3(s) + H_2O(\ell) + CO_2(g)$
    Based on Table E, identify the polyatomic ion in the solid product of the reaction.

11. *Potassium phosphate, K_3PO_4, is a source of dietary potassium found in a popular cereal…*
    Identify two types of chemical bonding in the source of dietary potassium in this cereal.

12. Identify both types of bonds in $NH_4NO_3(s)$.

NEW YORK STATE

CHEMISTRY REFERENCE TABLES

TABLE G

SOLUBILITY CURVES AT STANDARD PRESSURE

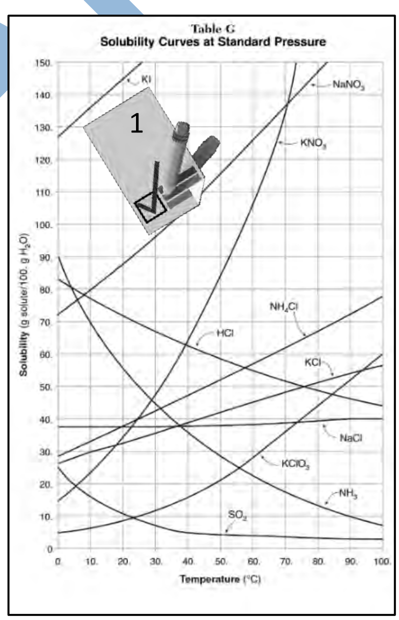


TABLE G: Solubility Curves at Standard Pressure

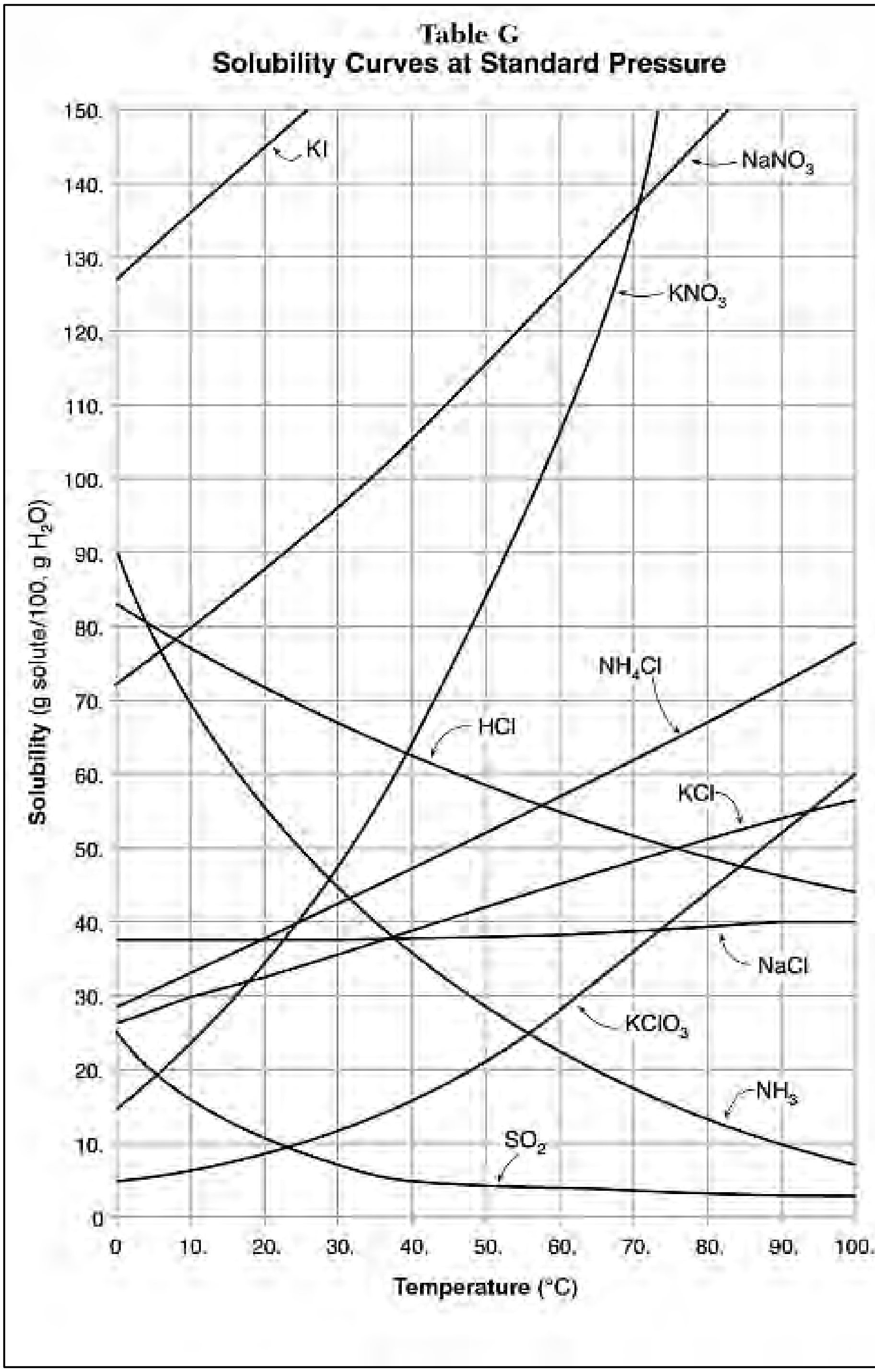


Table G is a graph that gives you the ***solubility trend*** for ten common substances (how much of that substance will dissolve in water) based on **temperature variations**:

- For **solid** and **liquid** solutes, as temperature *increases*, solubility *increases*.
- For **gas** solutes, as temperature *increases*, solubility *decreases*.

You can also use the table to determine ***saturation levels*** of given solutions.

- **Saturated solution** → a solution that is *filled to capacity* – it is holding (dissolved within it) the exact amount of solute it can hold.
- **Unsaturated solution** → a solution that is *not full*. It is still capable of dissolving more solute.

Reading the Table:

- Basic points about the graph:

  - The **horizontal axis** represents the **TEMPERATURE**, measured in *degrees Celsius (°C).* It ranges from 0 degrees to 100 degrees, with a scale of ten.

  - The **vertical axis** represents the **SOLUBILITY**, measured in *grams of solute per one hundred grams of water (g solute/100. g H_2O)*. It ranges from 0 grams to 150 grams, also with a scale of ten.

  - Each **dark labeled curve** on the graph represents a different compound. The seven curves sloping in an *upwards* direction [L → R] represent ***solid*** compounds, while the three curves sloping *downwards* represent ***gaseous*** compounds. (Because temperature has opposite effects on the solubility of solids and gases. See gray box on previous page.)

- Reading the graph:

  - Read *up* from the **TEMPERATURE** on the x-axis to the line labeled with the appropriate formula (or substance) and then to the *left* for the number of grams to make a saturated solution. The line represents a saturated solution for that formula at various temperatures.

  - The point where the temperature and solubility axis meet a curve tells you how many grams of this compound 100 grams of water can hold at this temperature. In other words, it gives you a solution made of that specific compound's *saturation level* at that temperature.

    - Ex: At **20°C**, a solution of 100 g of water can hold approximately **145 g** of **KI** [top left]. In other words, a solution of KI is *saturated* with 145 g at 20°C.

    - Ex: At **70°C**, a solution of 100 g of water can hold approximately **18 g** of **NH_3** [bottom right]. In other words, a solution of NH_3 is *saturated* with 18 g at 70°C.

    - Ex: At **30°C**, a solution of 100 g of water can hold approximately **67 g** of **HCl** [middle]. In other words, a solution of HCl is *saturated* with 67 g at 30°C.

  - If the point where the temperature (ex: **80°C**) and the number of grams – solubility (ex: **60 g**) meet is *below* that formula's curve, this means that a solution of this compound is *unsaturated* at this temperature. The solution would still be able to dissolve more solute.

    - Ex: A solution of 100 grams of water and **60 g** of **NH_4Cl** [middle right] at **80°C** is *unsaturated*, since at 80°C, the solution should be able to hold approximately 67 g of NH_4Cl, not just 60 g.

- ⇨ <u>Ex:</u> A solution of 100 grams of water and **110 g** of **KNO_3** [top right] at **70°C** is *unsaturated*, since at 70°C, the solution should be able to hold approximately 133 g of NH_4Cl, not just 110 g.

➔ Sometimes, you are asked how many more grams of solute a solution needs to become saturated at a specific temperature. To figure this out, simply **subtract** *the amount of solute currently dissolved* in the solution from *the amount of solute the solution can hold* when saturated.

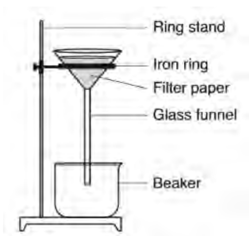
- ⇨ <u>Ex:</u> At **30°C**, **25.0** grams of **KCl**(s) are dissolved in 100. grams of H_2O(l). Based on Table G, determine the additional mass of KCl(s) that must be dissolved to saturate the solution at 30°C.
  - ✓ **Key:** At 30°C, the solution of KCl can hold about **35** g of solute. Currently, it only has 25 g. Subtract: $35 - 25 = \mathbf{10}$. *10 g of KCl must be dissolved to saturate the solution at 30°C.*

➔ **Note:** As you may have noticed, every problem we've worked with so far used ***100 grams*** of water as the amount of solvent (substance that is dissolving) in the solution. This is because that is the way **SOLUBILITY** is measured on this table: g of solvent per 100 grams of water. *<u>However</u>, the regents can present an example using only **50 grams** of water, or sometimes **200 grams** of water.* <u>Why is this important?</u>

- ⇨ If there are only ***50 g*** of water, the solution can only hold **half** of the amount of solute the graph seems to indicate that it can hold at this temperature, because there is only half the amount of solvent available to dissolve the solute.
  - ✓ <u>Ex:</u> At **90°C**, a solution of **50 g** of water is saturated with **20 g** of **NaCl** [bottom right] – half of 40 g.
  - ✓ <u>Ex:</u> At **40°C**, a solution of **50 g** of water is saturated with **2.5 g** of **SO_2** [bottom middle] – half of 5 g.
- ⇨ If there are ***200 g*** of water, the solution can hold **double** the amount of solute than the graph seems to indicate, because there is double the amount of solvent available.
  - ✓ <u>Ex:</u> At **10°C**, a solution of **200 g** of water is still *un*saturated with **100 g** of **NH_3** [bottom right], since it can hold 140 g – double 70 g – of NH_3 at this temperature.
  - ✓ <u>Ex:</u> At **30°C**, a solution of **200 g** of water is saturated at approximately **84 g** of **NH_4Cl** [middle right].

1. *At 23°C, 85.0 grams of $NaNO_3$(s) are dissolved in 100. grams of H_2O(ℓ).* Based on Table G, determine the additional mass of $NaNO_3$(s) that must be dissolved to saturate the solution at 23°C.

2. *In a laboratory investigation, a student is given a sample that is a mixture of 3.0 grams of NaCl(s) and 4.0 grams of sand, which is mostly SiO_2(s). The purpose of the investigation is to separate and recover the compounds in the sample. In the first step, the student places the sample in a 250-mL flask. Then,* ***50.*** *grams of distilled water are added to the flask, and the contents are thoroughly stirred. The mixture in the flask is then filtered, using the equipment represented by the diagram below.*



Based on Table G, state evidence that all the NaCl(s) in the flask would dissolve in the distilled water at 20.°C.

Questions 3 & 4: *A saturated solution of sulfur dioxide is prepared by dissolving SO_2(g) in 100. grams of water at 10.°C and standard pressure.*

3. Determine the mass of SO_2 in this solution.

4. Based on Table G, state the general relationship between solubility and temperature of an aqueous SO_2 solution at standard pressure.

5. According to Table G, which substance forms an unsaturated solution when 80. grams of the substance are stirred into 100. grams of H_2O at 10.°C?

(1) KNO_3 (3) KI
(2) NH_3 (4) NaCl

6. *A solution is made by dissolving 70.0 grams of KNO_3(s) in 100. grams of water at 50.°C and standard pressure.* Determine the number of additional grams of KNO_3 that must dissolve to make this solution saturated.

My Notes on the Previous Section(s):

ANSWERS

TO THE

REAL REGENTS QUESTIONS

ON THE

NEW YORK STATE

CHEMISTRY REFERENCE TABLES

Table B

1) **2** **($q = mC\Delta T$;** *$q = (75)(4.18)(15)$; $q \approx 4700$ J)*

2) **3** **($q = mH_f$;** *$q = (200)(334)$; $q = 66800$)*

3) **668 J** **($q = mH_f$;** *$q = (2)(334)$; $q = 668$)*

4) **113000 J** **($q = mH_v$;** *$q = (50)(2260$; $q = 113000$)*

5) **$q = (102.3)(2260)$**

Table E

1) **2** *(Table E)*

2) **3** *(Table E)*

3) **4** *(Table E)*

4) **1** *(See Table E and rules for writing chemical formulas.)*

5) **1** *(See Table E and rules for writing chemical formulas.)*

6) **1** *(See Table E and rules for writing chemical formulas.)*

7) **4** *(The bond is between two ions. One is a polyatomic ion found on Table E. The other one is what is "leftover" in the compound.)*

8) **3** *(Compounds that contain polyatomic ions have both ionic and covalent bonding.)*

9) **2** *(Compounds that contain polyatomic ions have both ionic and covalent bonding.)*

10) **Carbonate / CO_3^{2-}**

11) **Ionic and covalent**

12) **Ionic and covalent**

Table F

1) **Ca^{2+} / Ca^{+2}** *<u>Note:</u> "Ca" / "Calcium" is not correct, since the question asked for the formula of the ion, not for the element symbol or name.*

2) **$AgClO_3$ / silver chlorate** *(the only soluble compound among the choices)*

3) **Ag^{+} / Pb^{+} / Hg_2^{2+}**

4) **2** *($AgCl$ is the only compound among the choices that is insoluble.)*

5) **3** *(CO_3^{2-} is insoluble unless combined with Group 1 ions or ammonium. Since Na^{+} is a Group 1 ion, this makes the entire compound soluble.)*

6) **1** *(PO_4^{3-} is insoluble unless combined with Group 1 ions or ammonium.)*

7) **4**

Table G

1) **4-6 g** *(90-85=5 / 90-84=6 / 90-86=4)*

2) ***According to Table G, the salt solution is unsaturated. / The 3.0 g of salt dissolved in 50. g of H_2O has a concentration less than the solubility of NaCl on Table G at 20.˚C. / Table G indicates that the solubility of NaCl is greater than the amount in the sample.*** *(At 20˚C, 50 g of water can hold about 19 g of NaCl – and it only has 3 g. So, all the NaCl will dissolve.)*

3) **15-18 g** *(Find the point that the 10˚C line hits the SO_2 curve.)*

4) ***The solubility at 1 atm increases as the temp. decreases. / As the temp. of the solution increases, the solubility of SO_2 decreases. / At lower temps, more SO_2 can dissolve. / indirect/inverse relationship***

5) **3** *(the only choice that falls below the curve at 10˚ C and 80 g of solute)*

6) **12-16 g** *(The solution can hold approximately 83 grams – 13 more than is already dissolved.)*

87% of chemistry teachers recently surveyed claim that an average of **35%** of their students fail reference tables questions.

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