58 Questions for Solutions - You should be able to do ALL of these problems. Use a calculator, write all formulas, watch SF, and find the answers online at Arbuiso.com on the SOLUTIONS page. This is great practice for the celebration and the regents exam.

1. How many grams of ammonia (NH_3) saturate a 100 mL solution at 90°C?
2. How many grams of ammonia (NH_3) saturate a 575 mL solution at 90°C?
3. If you start with a 100 mL saturated solution of $KClO_3$ at 100°C and cool it rapidly to 25°C, how many grams of solute fall out as a precipitate?
4. If you start with a 364 mL saturated solution of $KClO_3$ at 100°C and cool it rapidly to 25°C, how many grams of solute fall out as a precipitate?
5. Explain the dynamic equilibrium that occurs in question 4.

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6. A 100 mL $NaH_2C_3O_{2(AQ)}$ at 20°C saturates at just 123 grams. A 100 mL $NaH_2C_3O_{2(AQ)}$ at 100°C saturates at 169 grams. If you start at 100°C , and cool it to 20°C, all 169 grams remain aqueous.
   How is this possible?
7. Explain the expression "when bonds form, energy is released" means. Tell how this expression works in relation to using a reusable handwarmer (we did this in the water lab).
8. Explain the expression "when bonds form, energy is released" means, in relation to boiling water and condensing steam.
9. What is the molarity of a sodium nitrate solution that contains 34.8 grams in 425 mL of solution?
10. If you have a 2.25 M $NaCl_{(AQ)}$ of 1550 mL, how many grams of NaCl are present?

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11. If a solution is 3.50 M and contains 671 grams of HCl, what volume is this solution?
12. If your stock solution is 8.65 M NaOH, how would you create a solution of 3.45 M and 225 mL $NaOH_{(AQ)}$?
13. Skip this one
14. What is the boiling point of a 3.75 M $KCl_{(AQ)}$ solution of one liter volume?
    (the BP elevation is 0.50 K/mole particles per liter)
15. What is the freezing point of a 3.75 M $KCl_{(AQ)}$ solution of one liter volume?
    (the FP depression is 1.86 K/mole particles per liter)

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16. Why does this KCl solution conduct electricity?
17. Does solid KCl conduct electricity? If not, why not. If yes, how?
18. Does MELTED, or molten KCl conduct electricity?
19. Is KCl an electrolyte?
20. Does Molten AgCl conduct electricity?
21. Is molten AgCl an electrolyte?

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22. Can you make up a 50.0 mL 5.00 M KCl using this 3.75 M $KCl_{(AQ)}$ solution? How, or why not?
23. Which cup would evaporate faster in a room, a 400. mL cup of pure water or a 400. mL cup of 1.00 M $NaCl_{(AQ)}$?
24. What does "like dissolves like" mean? Water is polar, name two molecular compounds that would dissolve into water, and two more that would not dissolve into water.

25. If a hot tub of 425 liters has a level of 7.50 PPM of sugar (a silly teenager melted some candy in it), how many grams of sugar are in this tub?
26. Draw six water molecules that surround these 2 ions that are floating in an aqueous solution. Make sure that the water molecules "orient" properly.

Define:

27. Solvent
28. Solute
29. Saturated
30. Supersaturated
31. Unsaturated
32. dynamic equilibrium
33. Molarity
34. Parts per million
35. Percent composition by mass
36. Freezing point depression (1.86 K/mole particles per liter)
37. Boiling point elevation (0.50 K/mole particles per liter)
38. Like dissolves like
39. Solvation
40. Electrolyte
41. Alloy
42. Solution
43. Stock solution
44. Colligative properties
45. Homogeneous
46. Heterogenous
47. Concentrated
48. Dilute

49. How many grams of HCl saturates a 425 mL solution at 40°C?

50. What is the molarity of the solution in question 49?

51. A student wants to prepare a 1.0 liter solution of a specific molarity. The student determines that the mass of solute needs to be 30. grams. What is the proper procedure to follow?
A. Add 1000. g solvent to 30. g solute
B. Add enough solvent to 30. g solute to make 1.0 L solution
C. Add 30 g. solute to 1.0 liters water
D. Add 30 g. solute to 970. mL water to make 1.0 L solution

52. In which sample of water do the molecules have the highest average kinetic energy?
A. 60. mL at 60.° C
B. 20. mL at 100.° C
C. 40. mL at 80.°C
D. 80. mL at 40.°C

53. The compound cryolite has a formula of Na_3AlF_6. Explain in terms of <u>ions</u> why molten cryolite, and aqueous cryolite both conduct electricity.

54. (June 06) Which ion, when combined with chloride ions, Cl^{-1}, forms an insoluble substance in water?
A. Fe^{2+}
B. Pb^{2+}
C. Mg^{2+}
D. Zn^{2+}

55. If 0.600 moles of $KOH_{(S)}$ are dissolved into water to form 400. mL of $KOH_{(AQ)}$, what's the molarity of the solution?

56. How many grams of $Ba(OH)_2$ are in one liter of $Ba(OH)_{2(AQ)}$ if the solution is 3.50 M?

57. A 100. mL saturated solution of KCl at 10°C has what molarity? (fill in the blank)

58. From a 4.25 M $CuCl_{2(AQ)}$ stock solution, <u>HOW MUCH STOCK SOLUTION</u> is needed to prepare a new solution that is 0.850 M and has a volume of 2.15 L?

Answers

1. How many grams of ammonia (NH_3) saturate a 100 mL solution at 90°C? Look at table G, it's 10 grams.
2. How many grams of ammonia (NH_3) saturate a 575 mL solution at 90°C?

90°C $\frac{NH_3}{Water}$ $\frac{10\text{ g}}{100\text{ mL}} = \frac{X\text{ g}}{575\text{ mL}}$ 100 X = 5750 X = 57.5 grams

3. If you start with a 100 mL saturated solution of $KClO_3$ at 100°C and cool it rapidly to 25°C, how many grams of solute fall out as a precipitate?
At 100°C this solution can hold 60 grams of potassium chlorate. If you cool it down to 25°C it can only hold 10 grams. 60 grams - 10 grams = 50 grams of precipitate
4. If you start with a 364 mL saturated solution of $KClO_3$ at 100°C, cool it rapidly to 25°C, how many grams of the potassium chlorate will precipitate?

100°C $\frac{KClO_3}{Water}$ $\frac{60\text{ g}}{100} = \frac{X\text{ g}}{364\text{ mL}}$ 100 X = 21840 X = 218 g will fit in this solution

25°C $\frac{KClO_3}{Water}$ $\frac{10\text{ g}}{100} = \frac{X\text{ g}}{364\text{ mL}}$ 100 X = 3640 X = 36.4 g will fit in this solution.

That means that starting with 218 g - 36.4 g = 181.6 = 182 grams will precipitate out (with 3 SF)

5. Explain the dynamic equilibrium that occurs in question 4.
At the bottom of the beaker will be about ~182 grams fo $KClO_{3(S)}$ which will continue to dissolve into the water, but at the same time, and importantly: AT THE SAME RATE, it will precipitate out of solution. There will be a steady amount on the bottom (182 g) and a steady amount dissolved (36.4 g), but the actual ions will keep changing places with each other at a constant rate.

6. A 100 mL $NaH_2C_3O_{2(AQ)}$ at 20°C saturates at just 123 grams. A 100 mL $NaH_2C_3O_{2(AQ)}$ at 100°C saturates at 169 g. If you start at 100°C , and cool it to 20°C, all 169 grams remain aqueous. How is this possible?

   Some compounds, this being one of them, can "supersaturate". That means when you start hot, and can dissolve more solute into a hot water solution, and gently cool it down, this compound can "trick" the water into keeping all of the solute dissolved. You can't mix it up cold, but if you start hot, then cool down, with a few compounds the solution ends up holding more solute than would be possible if you started out with colder water.

7. Explain the expression "when bonds form, energy is released" means. Tell how this expression works in relation to using a reusable handwarmer (we did this in the water lab).

   In chemistry, whenever a bond forms, it's more stable. So when bonds form, they release energy as they become more stable. If ionic bonds form, as with the reusable heat pads, they release energy.

8. Explain the expression "when bonds form, energy is released" means, in relation to boiling water and condensing steam.
To boil water the liquid needs enough energy to reach the boiling point, then 2260 J/g to break apart all of the hydrogen bonds holding them in the liquid phase. This turns water to steam. If steam condenses onto your finger, the gas H_2O condenses into the liquid phase. This releases lots of heat (you get burned) because as the hydrogen bonds between the molecules REFORM, to hold the molecules together as a liquid, energy is released. When ANY bonds form, energy is released. This is an exothermic process.

9. What is the molarity of a sodium nitrate solution that contains 34.8 grams in 425 mL of solution?

$$M = \frac{\#\text{ moles}}{\text{Liters}} = \frac{0.409\text{ moles}}{0.425\text{ L}} = 0.962\text{ M}$$

(the number of moles comes from 34.8 g X 1 mole/85 grams = 0.409 moles)

10. If you have a 2.25 M $NaCl_{(AQ)}$ of 1550 mL, how many grams of NaCl are present?

$$M = \frac{\#\text{ moles}}{\text{Liters}} \quad \frac{2.25\text{ M}}{1} = \frac{\#\text{ moles}}{1.55\text{ L}}$$

moles = 3.49 moles NaCl → 3.49 moles X 58 g/mole = 202 grams NaCl (3 SF)

11. If your stock solution is 8.65 M NaOH, how would you mix up a solution of 3.45 M and 225 mL $NaOH_{(AQ)}$?
$M_1V_1 = M_2V_2$ (8.65 M)(V_1) = (3.45 M)(225 mL) V_1 = 88.7 mL stock.

    Put the 84.5 mL stock into a flask, fill the flask with water up to the 225 mL mark (approx: 225mL - 88.7mL = water needed)

12. What is the boiling point of a 3.75 M $KCl_{(AQ)}$ solution of 1L volume?
373 K + (3.75 X 2 x 0.50 K) = 373 + 3.75 = 376.75 K (no SF)

13. Skip this one

14. What is the freezing point of a 3.75 M $KCl_{(AQ)}$ solution of 1 L volume?
 273 K -(3.75 X 2 X 1.86 K) = 273 - 13.95 = 259.05 K (no SF)

15. Why does this KCl solution conduct electricity? Any solution with LOOSE ions conducts electricity. All ionic compounds that are aqueous will not only dissolve to invisibly small particles, those particles are ions.

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16. Why does this KCl solution conduct electricity?
 A $KCl_{(AQ)}$ solution has loose or mobile ions, which conduct electricity.

17. Does solid KCl conduct electricity? If not, why not. If yes, how?
 Solid ionic componds CAN NOT conduct electricity, they do not have loose or mobile ions.

18. Does MELTED, or molten KCl conduct electricity?
 YES, molten means melted, which means loose ions. It would be crazy hot, but it would conduct electricity.

19. Is KCl and electrolyte?
 Yes, by definition, all ionic compounds that are aqueous (which form loose or mobile ions) are electrolytes, they conduct electricity in the aqueous phase.

20. Does Molten AgCl conduct electricity?
 Yes, all melted (or molten) ionic compounds conduct electricity, they have loose or mobile ions.

21. Is molten AgCl an electrolyte?
 NO! To be an electrolyte, the ionic compound must become aqueous. Since AgCl is INSOLUBLE in water, it is not an electrolyte, or able to conduct electricity.

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22. Can you make up a 50.0 mL 5.00 M KCl using this 3.75 M $KCl_{(AQ)}$ solution? How, or why not?
 No, you can only make solutions that are more dilute, not more concentrated in our high school course.

23. Which cup would evaporate faster in a room, a 400. mL cup of pure water or a 400. mL cup of 1.00 M $NaCl_{(AQ)}$?
 Water does not like to evaporate, but salty water evaporates even slower. The water is attracted to itself, and to the loose ions as well.

24. What does "like dissolves like" mean? Water is polar, name two molecular compounds that would dissolve into water, and two more that would not dissolve into water.
 Like dissolves like means that POLAR SOLVENTS can only dissolve POLAR SOLUTES, or
 that NONPOLAR SOLVENTS can only dissolve NONPOLAR SOLUTES.
 There are some exceptions on Table F, not all ionic compounds (which are polar) will dissolve into water.)

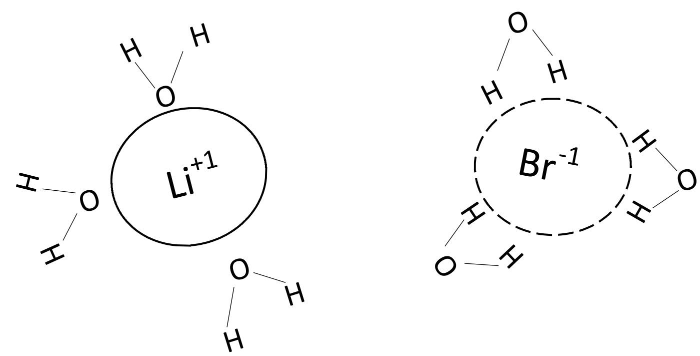
 Water is polar, it dissolves polar molecules, and most ionic compounds. Polar molecules that dissolve into water include HCl, NH_3, PCl_3, CH_3Br, and CH_3OH. Molecules that are nonpolar will not dissolve into water, including CH_4, CCl_4, N_2.

25. If a hot tub of 425 liters has a level of 7.50 PPM of sugar (a silly teenager melted some candy in it), how many grams of sugar are in this tub?

$$\text{PPM} = \frac{\text{Grams solute}}{\text{Grams solution}} \times 1{,}000{,}000 = \qquad 7.50 \text{ PPM} = \frac{X \text{ g}}{425{,}000 \text{ g}} \times 1{,}000{,}000$$

$$7.50 \text{ PPM} = \frac{X \text{ g}}{425 \text{ g}} \times 1{,}000 \qquad 7.50 \text{ PPM} = 2.35 X \qquad X = 3.19 \text{ g sugar}$$

Draw six water molecules that surround these 2 ions that are floating in an aqueous solution. Make sure that the water molecules "orient" properly.
The "negative" oxygen side of water attracts to the positive lithium cations. The "positive" hydrogen side of water attract to the negative bromide anions.



Define

27. Solvent — the part of the solution that the solute dissolve into. Salty water has water as the solvent.
28. Solute — the part of the solution that dissolve into the solvent. Salty water has salt as the solute.
29. Saturated — when a solution is holding the maximum solute for it's volume and temperature.
30. Supersaturated — when a hot saturated solution is allowed to cool down slowly, leaving more solute dissolved in the solution than you could stir in if you started with a cool solution. The excess solute remains aqueous until you disrupt it (by some disruption, possibly a bang or shock wave).
31. Unsaturated — when a solution has room to hold more solute at this volume or temperature.
32. dynamic equilibrium — when a saturated solution has so much solute that some remains parked at the bottom of the beaker, but some solute continues to dissolve at a constant rate, while the same amount precipitates out of solution at the same time. Always staying the same but always changing. The mass dissolved remains constant, as does the mass that is solid, but the actual individual particles keep changing phase from solid to aqueous.
33. Molarity — a measure of solution concentration, which is equal to moles of solute divided by liters of solution.
34. Parts per million — a measure of very, very dilute solutions,
    which is equal to grams of solute, divided by grams of solution, multiplied by 1,000,000
35. Percent composition by mass — another measure of concentration,
    equal to grams of the part divided by the grams of the whole, multiplied by 100%
36. Freezing point depression — How much the freezing point is lowered by the addition of one mole of particles dissolved in one liter of aqueous solution, which is 1.86 K/mole particles per liter
37. Boiling point elevation — How much the boiling point is increased by the addition of one mole of particles dissolved in one liter of aqueous solution, which is 0.50 K/mole particles per liter
38. Like dissolves like — refers to the polarity of the solvent and solute. Only polar solutes dissolve into polar solvents. Only nonpolar solutes dissolve into nonpolar solvents.
39. Solvation — the process of dissolving. This can also be called the dissociation or ionization of ionic compounds in water, or the breakdown of solid molecular compounds (like sugar) into individual molecules.
40. Electrolyte — an ionic compound that is aqueous will create loose or mobile ions. This solution conducts electricity. It is an electrolyte. Solid ionic compounds cannot conduct electricity cannot conduct electricity, but if the solid could become aqueous, the solid is also considered to be an electrolyte.
41. Alloy — a mixture of 2 or more metals, or metals and nonmetals, usually formed by melting them together, that when cooled to a solid, has slightly different properties. This is a homogeneous mixture, not a new substance.

Define

42. Solution — usually "wet" but can be solid, liquid or gas, is a homogeneous mixture where stuff dissolves into other stuff. Examples include metallic alloys (solid), aqueous solutions (liquid), or air (gas).
43. Stock solution — literally a solution that you have "in stock" that is already mixed and you know it's concentration.
44. Colligative properties — properties affected by the addition of solute, which include boiling point, freezing point, and vapor pressure.
45. Homogeneous — a solution that is mixed the same throughout
46. Heterogenous — a solution that is mixed differently throughout
47. Concentrated — a solution with a lot of solute (this is a qualitative measure)
48. Dilute — a solution with just a little solute (this is a qualitative measure)

49. How many grams of HCl saturates a 425 mL solution at 40°C?

40°C $\frac{\text{HCl}}{\text{water}}$ $\frac{62\text{ grams}}{100\text{ mL}} = \frac{X\text{ grams}}{425\text{ mL}}$ 100 X = 26,350 X = 264 grams HCl

50. What is the molarity of the solution in question 49?

$$M = \frac{\text{Moles solute}}{\text{Liters solution}} = \frac{\text{Moles solute}}{\text{Liters solution}} = \frac{7.33\text{ moles}}{0.425\text{ Liters}} = 17.2\text{ M HCl}_{(AQ)}$$

$$\frac{264\text{ g HCl}}{1} \times \frac{1\text{ mole HCl}}{36\text{ g HCl}} = 7.33\text{ moles}$$

$$\frac{425\text{ mL}}{1} \times \frac{1\text{ Liter}}{1000\text{ mL}} = 0.425\text{ Liters}$$

51. A student wants to prepare a 1.0 liter solution of a specific molarity. The student determines that the mass of solute needs to be 30. grams. What is the proper procedure to follow?
    B. Add enough solvent to 30. g solute to make 1.0 L solution. Always finish with the water, that way the new solution has a TOTAL volume including the solute.

52. In which sample of water do the molecules have the highest average kinetic energy?
    B. 20. mL at 100.° C - The key word is AVERAGE. That means go for the highest temperature.

53. The compound cryolite has a formula of Na_3AlF_6. Explain in terms of ions why molten cryolite, and aqueous cryolite both conduct electricity. This is an old regents question designed to mess you up because you are not used to seeing compounds with double cations. The first time I saw this on the regents it surprised me too. Ionic compounds form loose and mobile ions in aqueous solution. They are electrolyte solutions that conduct electricity. If you melt ANY ionic compound, the ions become loose and the melted/molten ionic compounds conduct as well. This stuff would ionize (or dissociate) this way: into water, Na_3AlF_6 forms $3Na^{+1}$ + Al^{+3} + $6\ F^{-1}$ (sums to 0)

54. Which ion, when combined with chloride ions, Cl^{-1}, forms an insoluble substance in water?
This is a table F question, look and see that the Pb (II) cation is the exception here B. Pb^{2+}

55. If 0.600 moles of $KOH_{(S)}$ are dissolved into water to form 400. mL of $KOH_{(AQ)}$, what's the molarity of the solution? Since molarity is equal to moles divided by liters, here it's 0.600 moles/0.400 liters = 1.50 M, with 3 SF

56. How many grams of $Ba(OH)_2$ are in one liter of $Ba(OH)_{2(AQ)}$ if the solution is 3.50 M? This solution must contain 3.50 moles of Ba(OH)2 dissolved. . $Ba(OH)_2$ has molar mass of (137 + 32 + 2) = 171 g/mole. 3.50 x 171 = 599 grams barium hydroxide (with 3 SF) or 598.5 grams on the calculator.

57. A 100. mL saturated solution of KCl at 10°C has what molarity? (fill in the blank) LOOK at table F to start.

At 10°C, there is 30 g KCl in 100 mL water. $\frac{30\text{ g KCl}}{1} \times \frac{1\text{ mole KCl}}{74\text{ g KCl}}$ = 0.41 moles KCl

$\frac{0.41\text{ moles KCl}}{0.100\text{ Liters}}$ = 4.1 Molar $KCl_{(AQ)}$

58. From a 4.25 M $CuCl_{2(AQ)}$ stock solution, HOW MUCH STOCK SOLUTION is needed to prepare a new solution that is 0.850 M and has a volume of 2.15 L?

$M_1V_1 = M_2V_2$ (4.25 M)(V_1) = (O.850 M)(2.15 Liters) V_1 = 0.43 Liters STOCK Solution

Put stock into a large beaker, then FILL beaker up to the 2.15 liter mark.
When making solutions like this, you can NEVER exactly know how much water to add.
It will be (approximately) 0.43 liters + X liters of water = 2.15 total liters of solution, which works out to ABOUT 1.62 liters water. The water and the solution do MIX a bit, and it's NOT like adding water to water. The only way to make a solution properly is to start with the solute (or the stock) and then fill to the proper volume with pure water.