ANSWERS TO UNIT III : THE PHYSICAL PROPERTIES AND PHYSICAL CHANGES OF SUBSTANCES

1. (a) any description using a **number**; for example: 5 s, 10 min, 3 h, 2 d.
   (b) any description using a **number**; for example: 5°C, 10 degrees hotter than room temperature.

2. (a) any **non–numerical** description; for example: in a moment, after a short while, a lifetime, quickly.
   (b) any **non–numerical** description; for example: hot, cold, room temperature.

3. The quantitative descriptions are in bold and the qualitative descriptions are underlined.

   Copper is a reddish–coloured element with a metallic lustre. It is an excellent conductor of heat and electricity, **melts at 1085°C and boils at 2563°C.** Archeological evidence shows that it has been mined for the past **5000 years** and presently is considered to be one of the most important metals available. Copper is insoluble in water and virtually all other solvents, reacts easily with nitric acid but only slightly with sulphuric and hydrochloric acids. It has a **density of 8.92 g/mL**, which makes it more dense than iron.

4. The tube could have been white–hot, **or** the tube could have been illuminated by a spotlight, **or** the tube could have been covered with a fluorescent white paint, **or** the tube could have been an operating fluorescent light bulb. You could cautiously feel if the tube is giving off heat **or** you could see if the tube still glows when shaded from light **or** investigate whether the tube has a source of electrical power.

5. (a) Observations are qualitative (non–numerical) facts whereas data are quantitative (numerical) facts.
   (b) An "observation" is a single qualitative fact whereas a "description" is a series of observations used to characterize something.
   (c) An observation is a fact recorded by our senses whereas an interpretation is the meaning which our mind gives to an observation.

6. Any of the terms listed can be wrong; even observations can be incorrect because our senses can be tricked (as magicians will tell you).

7. You might be biased in the way you interpret some of the observations. In fact, you might see only what you expect to see, even if something different actually occurred. Also, you might tend to use only data which agrees with your pre–conceived ideas and disregard data which contradicts your ideas.

8. A hypothesis; it is called an "assumption" and it is only a single idea.

9. This statement is not testable and makes no predictions. It could be a "belief" but not a scientific theory.

10. A law; the statement simply says what always occurs in a given situation.

11. (a) ***Hypothesis*** – a temporary idea put forward to explain the results of an experiment and based on initial experiments; intended to explain a narrow set of experimental results; initial confidence in a hypothesis may be low.
    Theory – a refined and extensively tested explanation of how and why related results are found; intended to explain a wide–ranging set of experimental results; level of confidence in a theory is generally very high.

    (b) ***Theory*** – attempts to explain why something occurs and to predict what is expected to happen in new circumstances; does not attempt to summarize past results of experiments.
    Law – summarizes experiments by describing what happens if a known situation occurs; does not predict what will happen in new situations and makes no attempt to explain **why** something occurs.

12. (a) & (b) – ask your Chem teacher to let you set up such an experiment. Science doesn't give "THE ANSWER" and you aren't going to get one here either. What happens inside an atom cannot be seen directly so scientists must be satisfied with their models. It can be tough on people who must have a "definite answer", but one has to get used to intrinsic uncertainties in science. No; whining won't help!

13. (a) physical property (The glass is not altered when light passes through it.)
    (b) physical property (Melted salt is still salt and solidifies to exhibit the same properties it had originally.)
    (c) chemical property (The properties of soap differ from those of lye and fat; soap is a new substance.)
    (d) physical property (Copper is not changed when electricity passes through it.)
    (e) chemical property (The white smoke is a new substance.)

14. light, heat, sound, etc. – in other words **ENERGY**!

15. Intensive = b, d, e, g Extensive = a, c, f

16. (a) density, melting temperature, lustre, malleability, ductility, electrical and heat conductivity, hardness, smell, taste
    (b) density, boiling temperature, freezing temperature, diffusion rate, viscosity, vapour pressure, electrical and heat conductivity, smell, taste
    (c) density, condensation temperature, diffusion rate, heat conductivity, smell, viscosity

17. (a) acetone
    (b) The lower the boiling temperature of a liquid, the higher its vapour pressure.
    (c) The higher the vapour pressure of a liquid, the faster its evaporation rate.
    (d) Iron is known to melt at a very high temperature and to boil at an even higher temperature. The relationship for part (b), above, implies that iron has a very low vapour pressure.
    (e) Since diethyl ether boils at a lower temperature than acetone, the relationship for parts (b) and (c) implies that diethyl ether has a higher vapour pressure and evaporation rate than acetone.

18. (a) The higher the temperature, the greater the diffusion rate.
    (b) ammonia
    (c) The smaller the mass of a molecule, the faster the diffusion rate.

19. (a) viscosity: hexane < carbon tetrachloride < glycerol
    (b) density: hexane < glycerol < carbon tetrachloride
    (c) There is no relationship between viscosity and density.

20. (a) the pressure increases
    (b) the volume decreases
    (c) When the pressure exerted on a gas increases, the volume of the gas **decreases.**
    (d) i) the volume decreases ii) the volume stays small when the pressure is released
    (e) i) the volume decreases ii) the volume increases back to its original value
    (f) The volume of a gas "recovers" back to its original value when an applied pressure is released.

21. Corn syrup has a HIGH viscosity because it has a high RESISTANCE to flow.
    Gasoline has a LOW viscosity because it has a low RESISTANCE to flow.
    If you heat a glass of syrup, the viscosity of the syrup decreases.

22. (a) intensive (b) extensive (c) extensive

23. The vapour pressure is quite low since very little ice evaporates and forms a vapour.

24. (a) liquid and gas (b) solid, liquid and gas (c) gas (d) solid (e) solid and liquid

25. liquid

26. (a) 22.4 mL (b) 22.4 L

27. (a) The pressure inside the balloon is equal to the pressure exerted by the atmosphere.
    (b) The balloon should expand because the pressure inside the balloon (pushing outward) is greater than the pressure outside (pushing inward).

28. Nothing regarding the densities can be predicted from a knowledge of the viscosities.

29. (a) According to exercise 18, the higher the temperature the greater the diffusion rate of a fluid (in this case the gaseous "scent" of the aftershave lotion). Therefore the scent of John's aftershave should travel faster to Juanita because of the higher temperature of the air carrying the scent.
    (b) According to exercise 18, lighter particles travel faster than heavier ones at the same temperature. Therefore, if the particles having a scent in John's aftershave are lighter in **mass**, Juanita will smell them first. (The property will be "diffusion rate" or "mass of particle".)

30. The sphere falls faster in chlorine gas. Chlorine has a lower viscosity, that is, a lower resistance to flow, and therefore the sphere will fall ("flow") faster in the chlorine.

31. Chloroform forms a VAPOUR because it boils above room temperature ($20^{o}C$).

32. According to exercise 17, since ethanol has a higher vapour pressure it has a lower boiling point.

33. (a) ion (b) molecule (c) atom (d) atom (e) ion (f) molecule

34. Four phases are mentioned: 1 = white sand, 2 = nails, 3 = salt water with some dye in it, 4 = gasoline. A 5th phase (air) may be above the phases described but is not mentioned as part of "this system".

35. Visible boundaries separating one phase from another must be present in a heterogeneous system. In a homogeneous system everything should look the same no matter which part of the system is examined.

36. (a) homogeneous
(b) heterogeneous (bark, leaves, roots, etc.)
(c) heterogeneous (shell, yolk, white)
(d) homogeneous

37. An element; the term "atom" is reserved for the smallest possible particle of gold and a 10 g piece of gold can be extensively subdivided.

38. They are similar in being homogeneous; they differ in that a compound is a pure substance while a solution is made of two or more pure substances.

39. (a) true solution
(b) mechanical mixture
(c) element, compound or true solution (a solid solution in this case)
(d) element, compound or true solution (such as air)
(e) element, compound or true solution (such as salt water)
(f) The first statement implies we have either an element or a compound. The second statement shows that at least two different substances can be produced and therefore we have at least two different types of atoms present. Conclusion: the substance was a COMPOUND.

40. (a) acetic acid
(b) iodine
(c) chloroform (present in smaller amount)
(d) silver nitrate (water is always the solvent, if present)

41. Sugar is a pure substance; dirt and air are mixtures

42. KCl(aq) refers to aqueous KCl or KCl dissolved in water

43. 6 (wood, lead, 2 colours of paint, metal end, eraser)

44. (a) compound (a single type of molecule)
(b) mixture (crust, cheese, etc.)
(c) mixture (water, carbonation, flavouring, etc.)
(d) compound (single type of molecule)
(e) mixture (two types of molecules)

45. The layer having the lower density will be on the top; that is, the water.

46. (a) distillation (b) evaporation, recrystallization, distillation (distillate can be discarded)

47. (a) distillation; solvent extraction may also work
(b) hand separation (pour off the top layer or use a separatory funnel), distillation (but why bother?)
(c) filtration, gravity separation (using a centrifuge)
(d) paper, column or thin–layer chromatography; you might try solvent extraction
(e) Filtration (separate sand from salt water); distillation (separate water from salt)

48. Recrystallization

49. amount left after one extraction = 0.10 = 10 %
amount left after two extractions = 0.10 x 0.10 = 0.010 = **1 %**

50. amount left after one extraction = 0.40 = 40 %
amount left after four extractions = 0.40 x 0.40 x 0.40 x 0.40 = 0.0256 = 2.6 %
therefore, amount removed = 100 % – 2.6 % = **97.4 %**

51. The idea is to let only one substance form crystals while the others remain in solution. If all the solvent evaporates, all the solids are deposited together and no separation occurs.

52. hand separation (pick out the good crystals by hand)

53. There may be more than one way to do this, but one way is:
- use filtration to remove the liquids from the sand and iron filings
- use a magnet to separate the iron filings from the sand
- use hand separation to pour off the gasoline from the water (or use a separatory funnel)
- distil off the water, leaving a mixture of dyes
- re–dissolve the dyes and use chromatography to separate them.

54. There may be more than one way to do this, but one way is:
    - use filtration to separate the liquids from the solids
    - use a gravity separation method to separate the two types of sand (put in a mechanical shaker and shake the dry sand; the heavier black sand will accumulate at the bottom of the container)
    - distil the methanol–hexanol mixture to separate the liquids.

55. - Solvent extract the mixture with alcohol. Only the naphthalene will dissolve. The alcohol can later be distilled off or evaporated to leave solid naphthalene.
    - Solvent extract the remaining solids with water. Only the potassium sulphate will dissolve. The water can then be distilled off or evaporated to leave solid potassium sulphate.
    - The calcium carbonate is the only solid left in the original mixture.

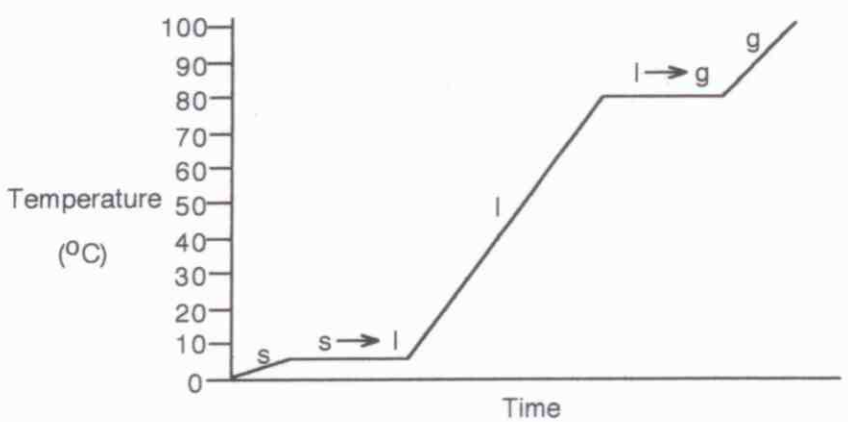
56. The mixture will appear as separate layers of aluminum powder, a solution of benzene and chloroform and a final layer consisting of a solution of sugar and water.
    - Filter off the aluminum, leaving two layers: benzene–chloroform solution and sugar–water solution.
    - Use hand separation or a separatory funnel to remove the benzene–chloroform layer from the sugar–water layer.
    - Distil the benzene–chloroform solution; the chloroform will come off first, leaving the benzene behind.
    - Distil the water, leaving the sugar behind (if the water was not wanted, the sugar–water solution could just be left in the open or on a hot plate to let the water evaporate.

57. Dissolve the powdered crystals in an appropriate solvent and use chromatography to separate the coloured chemicals from each other. This is appropriate because there is only a little of each chemical.

58. - First, use a magnet to remove the nails.
    - Next, put the remaining mixture through a sieve which allows the white sand and platinum to pass through while holding back the pennies.
    - Finally, use a mechanical shaker to allow the high density platinum to settle to the bottom while the white sand stays on top.

59. (a) physical change (water vapour condenses into droplets of moisture)
    (b) chemical change (new substances are formed: smoke and various cancer–causing chemicals)
    (c) chemical change (growth involves chemicals being produced and used up)
    (d) chemical change (rust is a new substance formed by the combination of iron, air and water)
    (e) physical change (no reaction has occurred to make new substances)
    (f) physical change (we are only separating substances, not producing new ones)

60.



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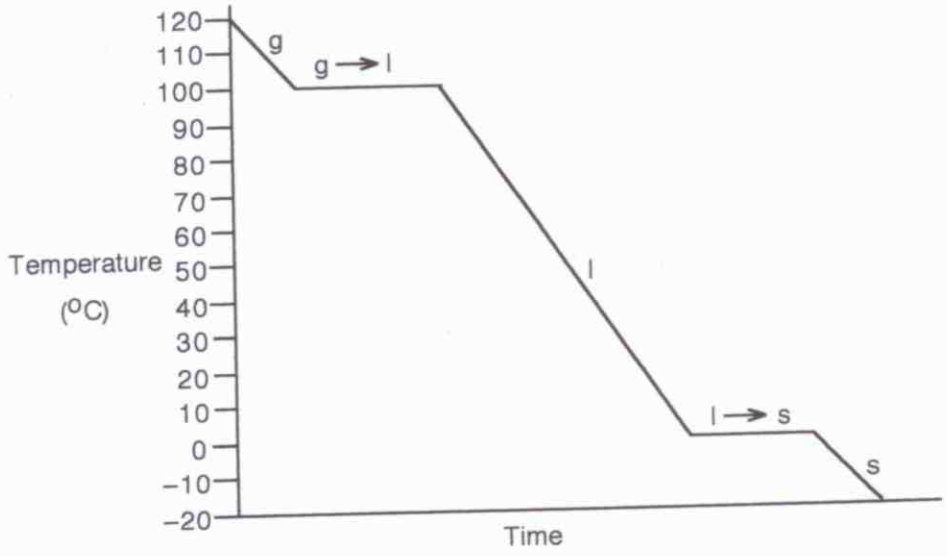

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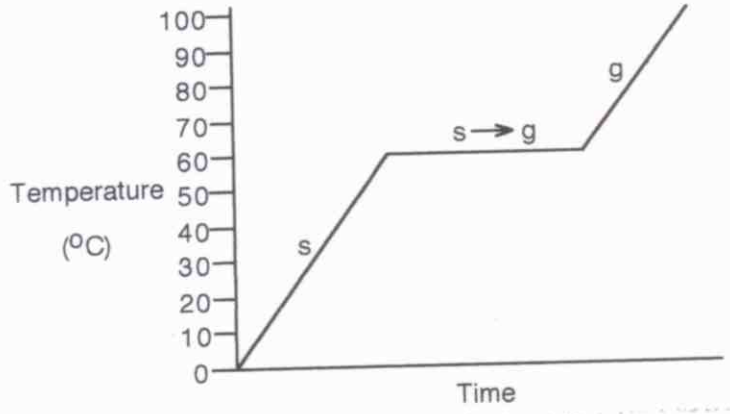

63. (a) At 5 minutes, the sample was about 75% ice and 25% water.
(b) At 10 minutes, the sample was about 50% ice and 50% water.

64. The kinetic energy of the particles increases.

65. translational

66. translational

67. translational and rotational

68. rotational and translational

69. The viscosity should decrease as the temperature increases. As temperature increases, the translational energy increases. This allows the molecules to move past one another faster and therefore they must have less resistance to "flow" past one another and possess a lower viscosity.

70. Many bonds in the molecules are identical to each other, so those parts of their spectra are identical.

71. The volume increases (recall that as the translational energy increases we change phase from solid to liquid to gas, and that the volume increases as we go from solid to liquid to gas).