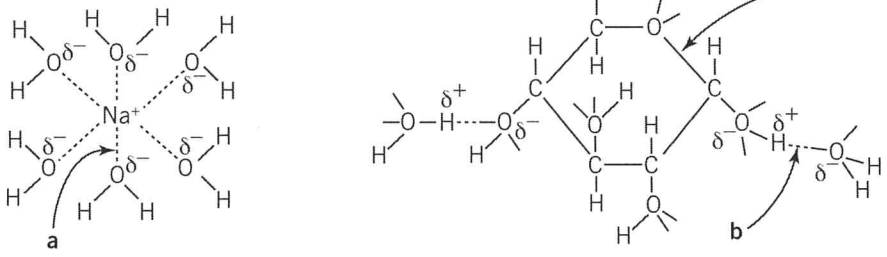
Worksheet 4.1
Water's solvent properties

NAME: **CLASS:**

INTRODUCTION

Due to its high polarity, water is an excellent solvent. This function is especially important in our bodies. Many nutrients need to be dissolved in the water in our blood so that they can be transported throughout the body. Water's capacity for hydrogen bonding contributes greatly to its solvent properties.

No.	Question	Answer
1	These diagrams show a sodium ion and a glucose molecule dissolved in water. Name the types of bonds indicated. 	
2	Why is glucose ($C_6H_{12}O_6$) more soluble in water than hexanol ($C_6H_{13}OH$) is, even though both molecules contain the same number of carbon atoms?	
3	What are three substances that are transported in dissolved form in our blood?	
4	Both water and ammonia can from hydrogen bonds, yet ammonia's boiling point is much lower than water's boiling point. Explain.	
5	Water's solvent capacity is also exhibited in seawater, which contains many dissolved substances. Name three ions that you would expect to find in seawater.	

6	There are 1.35×10^9 km^3 of seawater in the world. Assuming the average density of seawater is close to that of pure water (1.00 g mL^{-1}), calculate the mass of bromide ions present in the world's seawater if its concentration is 67 ppm of seawater. (1 km^3 = 10^{12} L)	

Gases are generally less soluble than many ionic compounds in water. The table below shows some solubility data for four gases.

Gas	Formula	Solubility (g/100g) at 0°C	Solubility (g/100g) at 20°C	Solubility (g/100g) at 40°C
Ammonia	NH_3	90	53	31
Hydrogen chloride	HCl	82	72	63
Oxygen	O_2	0.007	0.004	0.003
Nitrogen	N_2	0.003	0.002	0.001

No.	Question	Answer
7	What is the solubility trend as the temperature increases?	
8	Propose a reason for this trend.	
9	Divide the gases into two groups: polar and non-polar.	
10	How does polarity affect solubility?	
11	What types of bonds can each of the four gases form with water?	
12	Propose an explanation for why at 0°C ammonia is more soluble in water than hydrogen chloride, which in turn is more soluble than oxygen.	
13	Which gas would you expect to be totally insoluble at 60°C?	

14	How would the composition of freshly boiled tap water be different to that of cold tap water?	
15	Carbon monoxide (CO) is 1.5 times more soluble than nitrogen at 20°C. **a** How much CO could dissolve in 75 mL of water at 20°C? **b** Why would CO be a more soluble gas than N_2?	
16	Industrial plants releasing hot water into waterways like lakes and streams cause thermal pollution. How can this cause the death of marine animals?	

Worksheet 4.1: Solutions
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No.	Answer
1	**a** Ion–dipole bond **b** Hydrogen bond **c** Covalent bond
2	Glucose contains many more hydroxy groups that can hydrogen bond to water and thus increase solubility. Hexanol is largely non-polar.
3	Various answers possible. Examples include salt, sugars and amino acids.
4	Since ammonia has three polar hydrogens and only one lone pair, it can form an average of two hydrogen bonds with other ammonia molecules. Water has two polar hydrogens and two lone pairs, so it can form four hydrogen bonds with other water molecules.
5	Various answers possible. Examples include sodium, chloride, calcium, carbonate and sulfate.
6	$1.00\ g\ mL^{-1} = 1.00\ kg\ L^{-1}$ volume of seawater $= 1.35 \times 10^9\ km^3 = 1.35 \times 10^{21}\ L$ $m(H_2O)$ = density × volume $= 1.00 \times 1.35 \times 10^{21} = 1.35 \times 10^{21}$ kg $m(Br^-)$ in mg = concentration (ppm) × mass of 'solution' in kg $= 67 \times 1.35 \times 10^{21} = 9.0 \times 10^{22}$ mg
7	The solubility of gases decreases as temperature increases.
8	The gases are mostly only weakly bonded to water, so the increased kinetic energy, of the warmer water molecules, easily breaks these bonds, allowing the gases to escape into the air.
9	Polar: NH_3 and HCl; non-polar: O_2 and N_2.
10	Increased polarity means increased solubility.
11	All can form dispersion forces with water. For O_2 and N_2, these are the only intermolecular bonds present. NH_3 can hydrogen bond to water. HCl can form dipole–dipole bonds with water. (In fact, both NH_3 and HCl ionise in water—because they act as a base and an acid respectively.)
12	With water, NH_3 can form hydrogen bonds, but HCl only forms the weaker dipole-dipole bonds and in turn O_2 only forms dispersion forces.
13	N_2
14	The boiled water will contain little, if any, dissolved gas.
15	**a** $m(CO) = \frac{75}{100} \times 1.5 \times 0.002 = 0.00225$ g **b** CO is polar, while N_2 is not.

16	The hot water would not contain enough dissolved oxygen to support life.