Unit 2 Chemistry – Practice test questions:

Properties of water, solubility and analytical techniques

Note: This set of practice questions have been assembled from a variety of sources. Whilst they cover the topics that we have studied, they are not completely representative of every style of question in the forthcoming Term 3 test.

SECTION A – MULTIPLE CHOICE

1. 200 g of water and 200 g of ethanol are poured into identical beakers. Both are initially at the same temperature. Each beaker is heated by the addition of 5000 J of heat energy. Given that the specific heat capacities of ethanol and water are 2.4 J g^{-1} °C^{-1} and 4.2 J g^{-1} °C^{-1}, respectively, you would expect that, after heating, the temperature of the ethanol would be

A. the same as that of water because the amount of heat added was the same.
B. lower than that of water, because the specific heat capacity of ethanol is lower than that of water.
C. higher than that of water, because the specific heat capacity of ethanol is lower than that of water.
D. lower than that of water because the hydrogen bonds in ethanol are not as strong as those in water.

2. Which of the following ions will be present as spectator ions when aqueous solutions of copper(II) nitrate, $Cu(NO_3)_2$, and sodium hydroxide, NaOH, are mixed?

A. Na^+ and NO_3^-
B. Cu^{2+} and OH^-
C. Na^+ and OH^-
D. Cu^{2+} and NO_3^-

3. Given that the specific heat capacity of water is 4.2 J g^{-1} °C^{-1}, the energy (in joules) needed to heat 150 g of water from 25 °C to 80 °C would be given by

A. (4.2 × 150)/55 J
B. (4.2 × 55)/150 J
C. (25 × 80)/4.2 × 150 J
D. 4.2 × 150 × 55 J

4. When aqueous solutions of $Ca(NO_3)_2$, Na_2CO_3 and KCl are mixed together, a white precipitate forms. The compound that precipitates will be

A. $CaCO_3$
B. $CaCl_2$
C. $NaNO_3$
D. K_2CO_3

5. Water expands on freezing because ice

A. has a more ordered arrangement of H_2O molecules.
B. has a less ordered arrangement of H_2O molecules.
C. has covalent bonding between water molecules.
D. freezes at 0 °C.

6. Sodium chloride dissolves in water because

A. molecules of NaCl can ionise in water.
B. hydrogen bonds form between Na^+ ions and Cl^- ions.
C. ion–dipole bonds form between Na^+ ions and water molecules and between Cl^- ions and water molecules.
D. strong hydrogen bonds form between NaCl molecules.

7. 0.0530 g of sodium carbonate (M = 106.0 g mol^{-1}) was dissolved to form 50.0 mL of solution. The concentration of this solution would be

A. 0.001 06 g L^{-1}
B. 0.100 M
C. 0.106%(m/V)
D. 106 mg L^{-1}

8. The concentration of aluminium ions in a 0.20 M $Al_2(SO_4)_3$ solution is

A. 0.010 M
B. 0.020 M
C. 0.20 M
D. 0.40 M

9. An antacid solution is known to contain 0.400 g of $Mg(OH)_2$ (M = 58.3 g mol^{-1}) per 10.0 mL. When dissolved in water, the amount in moles of hydroxide ions, OH^-, in 1.00 L of the antacid solution would be closest to

A. 6.86×10^{-3}
B. 1.37×10^{-2}
C. 0.137
D. 1.37

10. In chromatography, the components of a mixture can be separated by the processes of adsorption and desorption. Desorption involves

A. the absorption of a solvent into the stationary phase.
B. the attachment of the components of the mixture to the stationary phase.
C. the movement of the mobile phase through the stationary phase.
D. the forming of bonds between the components of the mixture and the stationary phase.

11. Which of the following statements is *not* correct?

All forms of chromatography involve

A. the use of stationary and mobile phases.
B. the processes of adsorption and desorption.
C. a non-polar mobile phase.
D. a stationary phase with a high surface area.

12.

A supersaturated solution is one where the mass of solute dissolved in a given volume of solvent is

A. more than the mass of solute that is soluble at a given temperature.
B. equal to the mass of solute that is soluble at a given temperature.
C. less than the mass of solute that is soluble at a given temperature.
D. more than the maximum mass of solute that will dissolve at the standard temperature.

13.

The heat of vaporisation for water is 44 kJ mol^{-1}, this is higher than that for many other substances with similar molar masses. The main contribution to this relatively high value is the energy required to break the

A. covalent bonds within the water molecules.
B. covalent bonds between the water molecules.
C. hydrogen bonds within the water molecules.
D. hydrogen bonds between the water molecules.

14.

A group of VCE chemistry students evaporated a 120 mL sample of an aqueous sodium chloride solution and obtained 2.158 g of solid. The chloride ion concentration of this solution was

A. 0.507 M.
B. 0.0369 M.
C. 0.307 M.
D. 0.614 M.

15.

When an aqueous solution of copper(II) sulfate is added to which one of the following aqueous solutions will a precipitate **not** be expected to form?

A. Sodium carbonate.
B. Barium chloride.
C. Ammonium chloride.
D. Silver nitrate.

16.

The fertiliser ammonium nitrate, NH_4NO_3, is readily soluble in water, because the water molecules will form

A. dipole-dipole interactions with the ammonium nitrate molecules.
B. hydrogen bonds with the ammonium nitrate molecules.
C. dipole-dipole interactions with the ammonium and nitrate ions.
D. ion-dipole interactions with the ammonium and nitrate ions.

SECTION B – SHORT ANSWER

Question 1

Examine the table of gas solubilities in water below:

Gas	Solubility (g of gas per kg of water)		
	0°C	20°C	60°C
Oxygen	0.069	0.043	0.023
Carbon dioxide	3.4	1.7	0.58
Nitrogen	0.029	0.019	0.011
Methane	0.040	0.023	0.011
Ammonia	897	529	168

a. **Describe** the trend in gas solubilities with **decreasing** temperature:

_____

_____

(1 mark)

b. **Contrast** the trend of gas solubilities in water with that of soluble **ionic** substances:

_____

_____

(1 mark)

c. The first four gases in the table have markedly different solubilities with that of ammonia.

In the boxes below, draw a valence structure of **one** of the 1st four gases and **ammonia**. Use labels and brief points to **explain** the contrast in solubilities in water. Refer to **intermolecular** bonding in your explanation.

Oxygen / carbon dioxide / nitrogen / methane:	Ammonia:

(3+3 = 6 marks)

Question 2

Examine the table of heat capacities of some common substances below:

Substance	Heat capacity ($J\ g^{-1}\ °C^{-1}$)
Water	4.2
Ethanol	2.4
Iron	0.45
Lead	0.13
Copper	0.39
Sand	0.48

a. Explain what is meant by the term **heat capacity**:

_____

_____

_____

(1 mark)

b. 500mL of cold tap water at 14.0 °C water is heated in a 750g copper saucepan on a gas burner for 3.00 minutes during which its temperature rose to 86.0 °C.

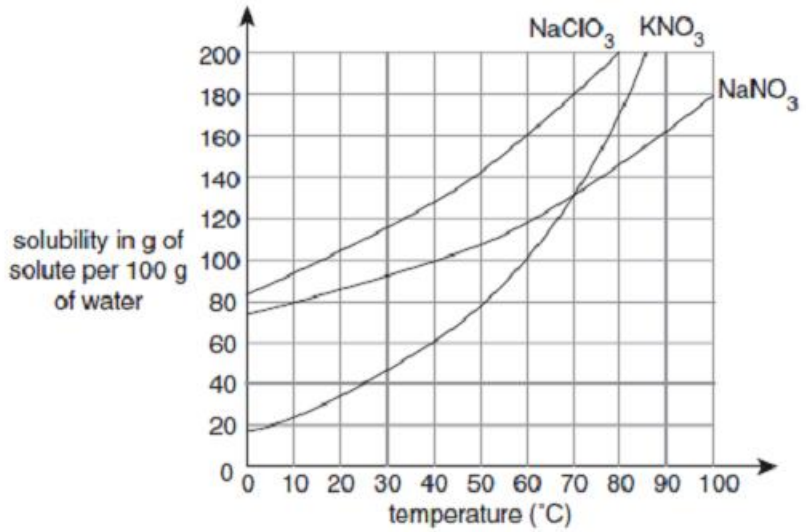
i. Calculate the amount of energy, **in kJ**, that was absorbed by the water.

ii. If no water had been added to the saucepan, what would its temperature have reached if the same amount of energy had been entirely absorbed by the copper? Assume its starting temperature was 19.0 °C and it is heated evenly throughout.

(2+2 = 4 marks)

Question 3

The graph below shows the solubilities of three metal salts: potassium nitrate, sodium nitrate and sodium chlorate:



a. At what temperature would 40g of sodium nitrate saturate 50mL of water?_____ (1 mark)

b. 100mL of a saturated solution of potassium nitrate is cooled from 80 °C to 50 °C. What mass of solid would be expected to crystallise out of solution?

(2 marks)

c. 50mL of water and 30g of each salt is placed in separate beakers. They are heated to exactly 30.0 °C and stirred. In which beaker/s will all of the salt dissolve? Show all working.

(3 marks)

Question 4

It's that time of the test when we have to see if you can write some equations. Yes, you. Yes, really!

Show all states.

(Do remember that *compounds* do *not* have the charges of their constituent atoms or ions on display – this is a very common mistake!)

Potassium hydroxide solution is added to copper (II) nitrate solution:

Full:_____

Ionic:_____

Write ionic equations for the following precipitation reactions, and name the spectator ions.

(a) $BaCl_2(aq) + CuSO_4(aq) \rightarrow BaSO_4(s) + CuCl_2(aq)$

_____

_____

(b) $BaCl_2(aq) + 2AgNO_3(aq) \rightarrow 2AgCl(s) + Ba(NO_3)_2(aq)$

_____

_____

(c) $CuSO_4(aq) + Pb(NO_3)_2(aq) \rightarrow PbSO_4(s) + Cu(NO_3)_2(aq)$

_____

_____

(d) $CuSO_4(aq) + K_2CrO_4(aq) \rightarrow CuCrO_4(s) + K_2SO_4(aq)$

_____

_____

(e) $2AgNO_3(aq) + Na_2CO_3(aq) \rightarrow Ag_2CO_3(s) + 2NaNO_3(aq)$

_____

_____

(f) $Pb(NO_3)_2(aq) + Na_2CO_3(aq) \rightarrow PbCO_3(s) + 2NaNO_3(aq)$

_____

_____

(g) $Pb(NO_3)_2(aq) + 2KI(aq) \rightarrow PbI_2(s) + 2KNO_3(aq)$

_____

_____

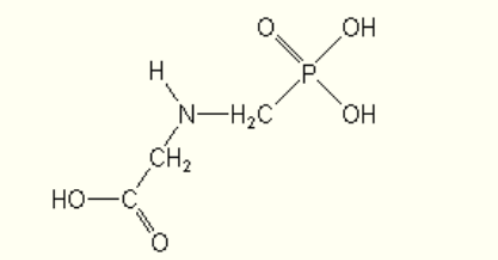
[7 × 2 = 14 marks]

5. For each of the following, circle the equivalent measurement from the list.

(a) 78 mg L^{-1} is equivalent to:	7.8 ppm	0.78 ppm	78 ppm
(b) 4.5%(w/w) KF is equivalent to:	4.5 mol L^{-1} KF	0.0077 mol L^{-1} KF	0.045 mol L^{-1} KF
(c) 36 µg g^{-1} is equivalent to:	0.036 mg g^{-1}	3.6 g kg^{-1}	0.0036%(w/w)
(d) 0.633 ppm is equivalent to:	0.000 63 ppb	0.633 ppb	633 ppb

[4 × 1 = 4 marks]

6. Glyphosate, *N*-(phosphonomethyl)glycine, is a broad spectrum systemic herbicide used to kill weeds, especially annual broadleaf weeds and grasses known to compete with commercial crops grown around the world.



In an analysis to check the level of glyphosate that may be entering a stream bordering a property using glyphosate, several 10.0 mL samples of stream water were collected and analysed using HPLC. Sample A was collected during a relatively dry period and sample B was collected after a heavy downpour. The results of the analysis of these two samples are given below, along with the results from a set of standards.

Glyphosate concentration (µg mL^{-1})	**Peak area**
0	0
10.0	235
20.0	458
30.0	684
40.0	922
50.0	1150
Sample A	252
Sample B	820

(a) Draw the calibration curve using the data in the table.

(b) Determine the concentration of glyphosate in μg mL^{-1} in samples A and B.

_____

_____

(c) Determine the mass of glyphosate in each sample.

_____

_____

(d) By referring to the structure of glyphosate, suggest a reason for the different readings obtained for the two samples.

_____

_____

[4 × 2 = 8 marks]