01 Matter, Mixtures and Separation

Set B **Answer key**

A Competition questions

29 MARKS

1 **A** diagram A [1]

In A every molecule holds two kinds of atom, so each is a compound, and there are two different kinds of molecule: a mixture of compounds.

B mixes one compound with an element (molecules of one kind of atom). C is a mixture of two elements as single atoms. D holds only one compound.

2 **C** Z, Y, W, X [1]

Z holds atoms and molecules of elements together with molecules made of two kinds of atom: a mixture of elements and compounds (1). Y holds two kinds of separate atom: a mixture of elements (2).

W holds molecules each made of two identical atoms: molecules of an element (3). X holds molecules each made of two different atoms: molecules of a compound (4).

3 **D** 85 °C [1]

A substance is a liquid between its melting point and its boiling point.

At 85 °C, Q (70 to 500 °C) and T (0 to 99 °C) are liquids. P (50 to 80 °C) and R (65 to 67 °C) have boiled, and S is a gas.

At −20 °C and −15 °C no two substances are liquid at once. At 15 °C only T is a liquid.

4 **C** freezing [1]

Energy is released and stronger attractions form, so the particles end up more tightly held. The distance hardly changes, so they were already close together: a liquid turning into a solid.

Condensation also releases energy, but the particles move from far apart to close together. Boiling and melting absorb energy.

5 **A** W and X [1]

Particles are far apart in a gas. A substance is a gas at 0 °C if its boiling point is below 0 °C: W (−89 °C) and X (−33 °C).

Y boils at 59 °C, so it is a liquid at 0 °C. Z melts at 44 °C, so it is a solid.

6

A closely packed, moving freely [1]

−75 °C lies between the melting point (−82 °C) and the boiling point (−60 °C), so hydrogen sulfide is a liquid.

In a liquid the particles are closely packed but move about, sliding past one another. Vibrating about fixed positions describes a solid, and far apart describes a gas.

7

C chlorine [1]

A substance is a liquid between its melting point and its boiling point. Chlorine melts at −101 °C and boils at −35 °C, so it is a liquid at −90 °C.

Argon has already boiled (−186 °C), so it is a gas. Bromine (−7 °C) and sulfur dioxide (−75 °C) have not yet melted, so they are solids.

8

C solid, liquid, gas [1]

Argon is below its melting point (−189 °C), so it is a solid. Oxygen is between its melting point (−218 °C) and boiling point (−183 °C), so it is a liquid.

Nitrogen is above its boiling point (−196 °C), so it is a gas.

9

B carbon dioxide [1]

As the mixture cools, the first compound to become a solid is the one that turns solid at the highest temperature.

Carbon dioxide turns straight from gas to solid at −78 °C. The others solidify only at their melting points: hydrogen sulfide at −85 °C, butane at −135 °C and propane at −188 °C.

10

D Diffusion is slower in dish 2 because the mass of the particles is greater. [1]

The colour spread less far in dish 2 in the same time, so diffusion is slower there.

$K_2Cr_2O_7$ has the larger M_r (294 against 158), so its particles are heavier, move more slowly and diffuse more slowly.

11

C fractional distillation [1]

Ethanol (II) and water (V) are miscible, so they do not form layers and liquid–liquid extraction does not work.

Fractional distillation separates miscible liquids with different boiling points. Ethanol boils at 78 °C and water at 100 °C.

Thin layer chromatography and recrystallisation are not used to separate two liquids.

12 **C** fractional distillation, separating funnel, simple distillation [1]

Ethanol and water are miscible liquids with different boiling points, so fractional distillation separates them.

Oil and water are immiscible and form layers, so a separating funnel separates them.

Water is the solvent in calcium chloride solution, and simple distillation collects the pure solvent from a solution.

13 **B** Y by fractional distillation, Z using the separating funnel [1]

Y will distil first since it has a lower boiling point than Z.

Y floats on Z, because Y is less dense. The lower layer, Z, is run off through the tap first.

14 **A** 100 °C, colourless [1]

Simple distillation collects the pure solvent. Only water vaporises and condenses, and the dissolved iron(II) sulfate stays in the flask, so the distillate is colourless.

The thermometer bulb is at the side arm, so it reads the temperature of the vapour leaving, which is water boiling at 100 °C.

15 **B** butanol and pentanol [1]

The flask is heated in a water bath, and water cannot go above 100 °C.

Ethanol (79 °C) and propanol (97 °C) boil below 100 °C, so they distil over. Butanol (117 °C) and pentanol (138 °C) boil above 100 °C, so they stay in the flask.

16 **A** fractional distillation, then crystallisation [1]

X and Y are miscible liquids, so they are separated by fractional distillation. Y has the lower boiling point and distils off first.

Z stays dissolved in X. Z decomposes on heating, so it is obtained by crystallisation, not by evaporating to dryness.

17 **D** Add water, filter, crystallise and sublime. [1]

Adding water and filtering removes the iron, which is insoluble. The filtrate holds both salicylic acid and sodium iodide.

Crystallising gives a solid mixture of the two, and gentle heating then sublimes the salicylic acid away from the sodium iodide. Options A and B never remove the sodium iodide, and a sublimation step needs a solid, not a solution.

18

D Q is filtered and the filtrate is allowed to evaporate to dryness to obtain sulfur. [1]

Sulfur dissolves well in carbon disulfide but carbon does not, so Q is a solution of sulfur with solid carbon in it. Filtering leaves the carbon as the residue, and evaporating the filtrate leaves the sulfur.

Sulfur is only slightly soluble in water, so P gives little sulfur. In C the residue is the carbon, not the sulfur.

19

B 0.25 [1]

X is the most polar since the two oxygens are highly electronegative, so its intermolecular hydrogen bonds are stronger than those of Y. Z has only permanent dipole–permanent dipole interactions, while W has only instantaneous dipole–induced dipole interactions.

In order of increasing polarity: W, Z, Y, X. The less polar a molecule is, the further it moves up the plate.

R_f of Y = $\frac{25 - 12.5}{50} = 0.25$

20

B ethanol [1]

A solvent separates the colours only if every colour has a different R_f value in it.

In ethanol the values are 0.5, 0.7, 0.8 and 0.6, all different. In water, E and F are both 0.3. In propanone, E and H are both 0.6. In hexane, F and H are both 0.2.

21

B Substance X will have the same R_f value when the solvent is changed to water. [1]

R_f changes when the solvent changes, so a value found in ethanol cannot predict the value in water.

The other statements follow from the values. A lower R_f means a less soluble substance. 0.20 is one-fifth of the distance moved by the solvent front. In the same run, 0.80 ÷ 0.20 = 4, so Y moves four times as far as X.

22

C 0.56 [1]

Distances are measured from the baseline. S moved 6.0 cm and the solvent front moved 6.0 + 4.7 = 10.7 cm.

$R_f = \frac{6.0}{10.7} = 0.56$

The 1.8 cm below the baseline and the 4.5 cm above the solvent front are not part of either distance.

23

B 0.30 [1]

The least soluble dye moves the shortest distance, so it is the spot at 5.0.

Distances are measured from the start at 2.0. The dye moved 5.0 − 2.0 = 3.0 and the solvent front moved 12.0 − 2.0 = 10.0.

$R_f = \frac{3.0}{10.0} = 0.30$

24 **D** Z has a larger R_f value than X. [1]

Z's spot is higher than X's spot, so Z moved further and has the larger R_f value.

W does not contain Y, because W has no spot at the upper level of Y. X is less soluble than Z, because it moved less far. Y has two spots, so it has two components.

25 **B** 6 [1]

In chromatogram A the dyes separate into spots in a line. The second run, in ethanol at right angles, separates each of those spots further.

Each spot on chromatogram B is a separate dye. There are 6 spots, so there are 6 dyes.

26 **C** Y ÷ X [1]

R_f = distance moved by the substance from the baseline ÷ distance moved by the solvent front from the baseline.

Y runs from the baseline to S and X runs from the baseline to the solvent front, so R_f = Y ÷ X. W and Z are measured from the solvent level, not the baseline.

27 **B** a mixture [1]

X melts over a range of temperatures, from −180 °C to −160 °C.

A pure substance, element or compound, melts at one temperature. A mixture melts over a range, so X is likely to be a mixture.

28 **C** crystallisation, 170 °C [1]

X melts over a range of temperatures, so it is an impure solid. A solid is purified by crystallisation.

A pure substance melts sharply at one temperature, and impurities lower the melting point, so pure X melts above 168 °C, at 170 °C.

29 **B** 102 °C [1]

Dissolved X is an impurity in the water, and an impurity raises the boiling point, so the water boils a little above 100 °C.

Only a small quantity of X is present, so the boiling point rises only slightly, to 102 °C, and stays far below the 118 °C of pure X.