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| School | Candidate's Name (PLEASE PRINT) |
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WINCHESTER
COLLEGE

Election

2022

Science

CHEMISTRY

THEORY SECTION

Recommended time: 20 minutes

Write all your answers in the spaces on this question paper

Reactivity Series Question

1 The reactivity series of metals lists the order of reactivity of the metals with the most reactive first.

(a) Complete a word equation for the reaction between the following chemicals. If there is no reaction, state 'no reaction'.

lead chloride + sodium → _____ [1]

(b) Magnesium sulphide and Zinc oxide both react with strontium but not with chromium. Use this information and your own knowledge of the reactivity series to put the four metals, chromium, magnesium, strontium and zinc in reactivity series order.

..... [1]

(c) The reaction between iron oxide and carbon monoxide is an example of a redox reaction. This is used in a blast furnace to produce iron.

iron oxide (s) + carbon monoxide (g) → iron (s) + carbon dioxide (g)

(i) What process is the iron oxide undergoing?

..... [1]

(ii) Why might rain in the areas around a blast furnace turn universal indicator paper orange?

.....

.....

..... [2]

[Total: 5]

Pigment Analysis Question

2 A chemist analysed a bottle of black ink. Some inks consist of pigments (colours) dissolved in a solvent. Others consist of *colloids* – tiny particles of *solid* pigments dispersed, but not dissolved, in a liquid. The ink investigated by the chemist contains only pigments dissolved in water.

(a) State a **chemical** test, and its result, which would show that the ink contains water.

.....
..... [2]

(b) Name the method the chemist would use to obtain a sample of pure water from the ink.

..... [1]

A sample of the black ink was placed near the bottom right corner of a piece of filter paper, on a base line. The bottom edge of the paper was suspended in a trough of water, and the water was allowed to soak up the paper to a height of 12 cm above the base line. The paper was then removed from the water and dried carefully. Once dry the paper was rotated 90° clockwise, and then suspended in a different solvent (propanone). This was allowed to soak up the paper to a height of 15 cm above the base line, as shown. The black ink separated into different coloured pigments, as shown on **Figure 1** overleaf. **The scale in the diagram is 1 square = 1 cm.**

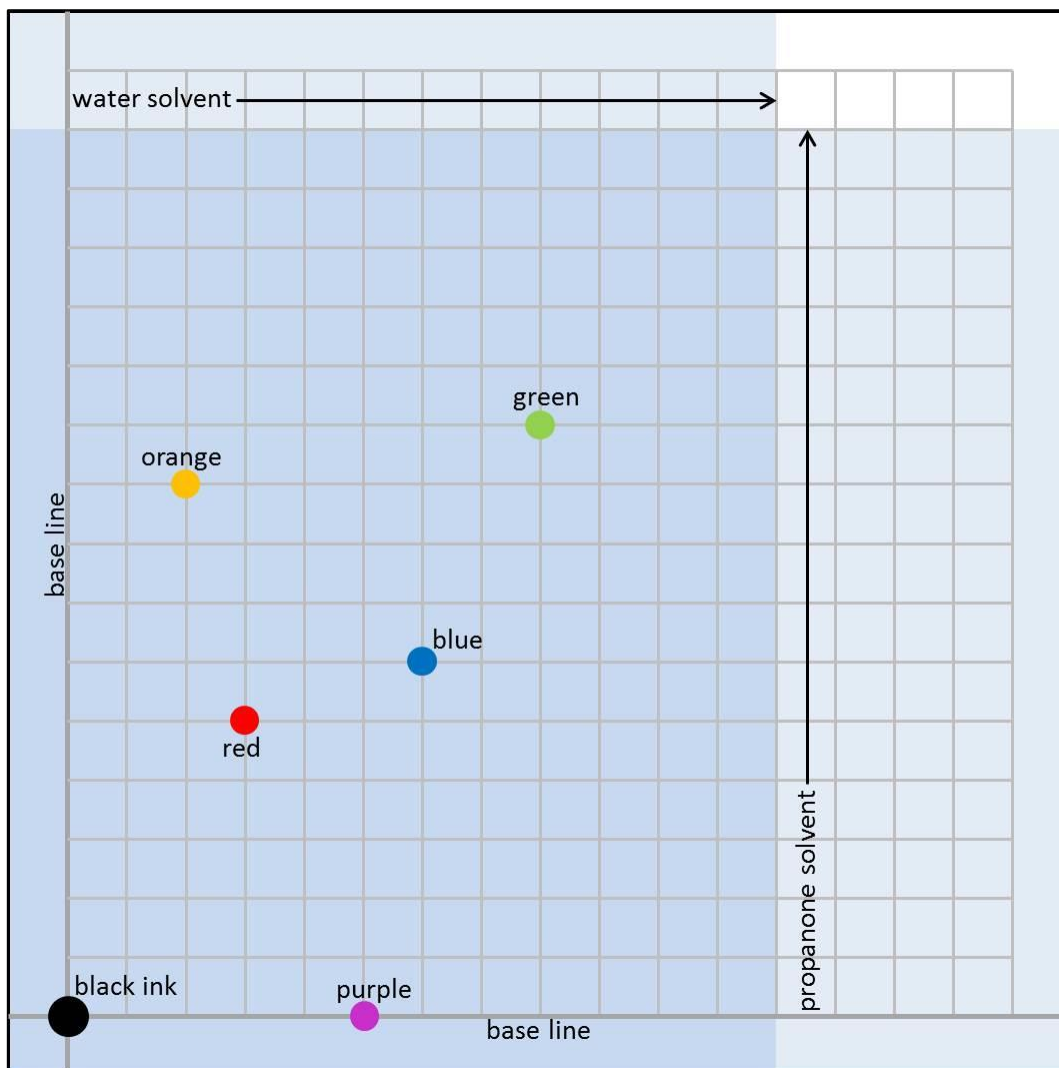
(c) Name the technique used by the chemist.

..... [1]

(d) Explain why the purple spot has not moved upwards from the base line.

.....
..... [1]

Figure 1 – image of filter paper obtained from black ink sample
(with the original position of black spot also shown)



The Retention Factor (R_f) of a particular substance in a particular solvent can be calculated using the formula:

$$R_f \text{ value} = \frac{\text{distance moved by spot (cm)}}{\text{distance moved by solvent front (cm)}}$$

- (e) Calculate the R_f value for the red compound in the water solvent.
Show your working.

.....
.....

Optional space for working is available below questions (f) - (h).

(f) Which colour has the same R_f value in both solvents?

..... [1]

(g) List all of the colours which have a lower R_f value in water than in propanone.

.....
..... [2]

(h) The black ink contained a sixth compound, X. The R_f value for X in water is 0.33, and the R_f value for X in propanone is 0.8. Using the letter X, show on the diagram the position in which the spot of compound X would be found.

[2]

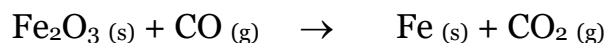
[Total: 12]

Optional space for working:

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Reaction Equations Question

- 3 The word equation for the blast furnace reaction in question 1 can be rewritten as a symbol equation:

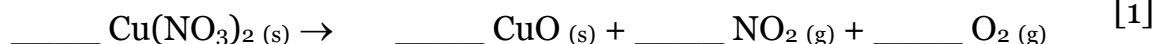


However, to be a properly balanced equation the number of atoms of each element involved must be the same when moving from the reactant side of the equation to the product side. Put more formally, chemical reactions do not create or destroy matter, they simply redistribute it.

- (a) Put whole numbers in the blank spaces in front of each chemical formula to make the reaction equation below a balanced equation.



- (b) When copper(II) nitrate solid is heated the solid changes to a black colour and a brown gas is seen to be evolved. The unbalanced reaction equation is given below. As in part (a) put whole numbers in the blank spaces in front of each chemical formula so that the equation becomes balanced.



- (c) Given that the relative masses (in *atomic mass units*) of Cu, N and O are 64, 14 and 16 *amu* respectively.

- (i) Calculate the relative mass (in *amu*) of copper(II) nitrate.

.....

.....

[1]

- (ii) Calculate the total mass of gas given off in *grams* when 37.6 *grams* of copper(II) nitrate is heated.

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[3]

- (iii) Mass spectrometers are sophisticated machines that can measure the relative masses of atoms to a very high degree of accuracy. For example, mass spectrometers can be used to show that samples of copper contain two types of atom with differing subatomic structure, ^{63}Cu and ^{65}Cu , such that the average mass of a copper atom is 63.546 *amu* to 3 decimal places (3 d.p.). Use this information to calculate the percentage of copper atoms which will be ^{63}Cu in any sample of copper.

.....
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[2]

[Total: 8]

End of this paper