Question 32 **(13 marks)**

Some students were asked to identify the 'best' cleaning solvent for the removal of graffiti from concrete. They were given black spray paint and five different cleaning solvents.

The students sprayed five different 10 cm by 10 cm areas of a concrete wall with the black paint and allowed the paint to dry for 24 hours. They then used 100 mL of cleaning solvent to try to remove the black paint, with a different cleaning solvent being used for each square. The students subsequently ranked the cleaning solvents from 1 to 5 based on their ability to dissolve the black paint with 1 being the best and 5 being the worst.

The results of the students' investigation, plus some information about the composition of each cleaning solvent, are shown in the table below.

Solvent	Investigation ranking	Composition of cleaning solvent
distilled water	5	water
turpentine	2	straight-chain hydrocarbons containing ten carbon atoms and one double bond
acetone	3	propanone
white spirit	1	straight-chain hydrocarbons C7 to C12
methylated spirits	4	5% methanol, 95% ethanol

(a) Identify the independent and dependent variables in the students' investigation. (2 marks)

Independent variable	
Dependent variable	

(b) State **two** variables that the students needed to control in their investigation. (2 marks)

One: _____

_____

Two: _____

_____

(c) What could the students do to ensure that their investigation was:

(i) valid? (1 mark)

(ii) reliable? (1 mark)

(d) Identify **two** safety risks associated with the students' investigation and state how each risk could be minimised. (4 marks)

Safety risk	How to minimise the risk

(e) Paints contain, among other things, a pigment (which is the paint colour) and a solvent (which dissolves the pigment). When paint dries, the solvent evaporates, leaving the pigment behind.

Use this information, the students' results and your knowledge of chemistry to identify the predominant type of intermolecular force occurring between the pigment molecules in the black paint used by the students. Explain your reasoning. (3 marks)