**CHEMISTRY UNIT 1**

**Semester One Examination 2017**

**Question/Answer Booklet**

 Student Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

 Teacher’s Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

# TIME ALLOWED FOR THIS PAPER

## Reading time before commencing work: ten minutes

Working time for the paper: two and a half hours

# MATERIALS REQUIRED/RECOMMENDED FOR THIS PAPER

**To be provided by the supervisor:**

This Question/Answer Booklet

Multiple-choice Answer Sheet

Chemistry Data Book

**To be provided by the candidate:**

Standard items: pens (blue/black preferred), pencils (including coloured), sharpener,

 eraser, correction tape/fluid, ruler, highlighters

Special items: up to three non-programmable calculators approved for use in the

 WACE examinations

# IMPORTANT NOTE TO CANDIDATES

No other items may be taken into the examination room. It is **your** responsibility to ensure that you do not have any unauthorised notes or other items of a non-personal nature in the examination room. If you have any unauthorised material with you, hand it to the supervisor **before** reading any further.

**Structure of this paper**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Section** | **Number of questions available** | **Number of questions to be answered** | **Suggested working time****(minutes)** | **Marks available** | **Percentage of exam** |
| **Section One:****Multiple-choice** | 20 | 20 | 40 | /40 | /25 |
| **Section Two:****Short answer** | 10 | 10 | 50 | 55 | /35 |
| **Section Three:****Extended answer** | 4 | 4 | 60 | /65 | /40 |
|  | /100 |

**Instructions to candidates**

1. Answer the questions according to the following instructions.

Section One: Answer all questions on the separate Multiple-choice Answer Sheet provided. For each questions shade the box to indicate your answer. Use only a blue or black pen to shade the boxes. If you make a mistake, place a cross through that square then shade your new answer. Do not erase or use correction fluid/tape. Marks will not be deducted for incorrect answers. No marks will be given if more than one answer is completed for any question.

Sections Two and Three: Write your answers in this Question/Answer Booklet.

2. When calculating numerical answers, show your working or reasoning clearly. Express numerical answers to the appropriate number of significant figures and include appropriate units where applicable.

3. You must be careful to confine your responses to the specific questions asked and to follow any instructions that are specific to a particular question.

4. Spare pages are included at the end of this booklet. They can be used for planning your responses and/or as additional space if required to continue an answer.

* + Planning: If you use the spare pages for planning, indicate this clearly at the top of the page.
	+ Continuing an answer: If you need to use the space to continue an answer, indicate in the original answer space where the answer is continued, i.e. give the page number. Fill in the number of the question(s) that you are continuing to answer at the top of the page.

5. The Chemistry Data Book is **not** to be handed in with your Question/Answer Booklet.

**Section One: Multiple-choice 25% (40 marks)**

This section has **20** questions. Answer **all** questions on the separate Multiple-choice Answer Sheet provided. For each question, shade the box to indicate your answer. Use only a blue or black pen to shade the boxes. If you make a mistake, place a cross through that square then shade your new answer. Do not erase or use correction fluid/tape. Marks will not be deducted for incorrect answers. No marks will be given if more than one answer is completed for any question.

Suggested working time: 40 minutes.

1. An 56Fe2+ ion contains:
	1. 56 electrons, 56 protons and 26 neutrons.
	2. 26 electrons, 26 protons and 30 neutrons.
	3. 24 electrons, 26 protons and 30 neutrons.
	4. 24 electrons, 30 protons and 26 neutrons.
2. Substance X is a solid that melts at 1520 oC. The substance X conducts electricity in both the solid and liquid states.

Which of the following is most likely to be the structure/property of X?

* 1. Metallic
	2. Ionic
	3. Covalent molecular
	4. Group 17 element
1. The following three-dimensional structure can be used to explain which one of the following species?

* 1. MgO
	2. Diamond
	3. Cu(NO3)2
	4. Na
1. Which of the following elements has only three valence electrons?
	1. Lithium
	2. Boron
	3. Nitrogen
	4. Neon
2. Which of the following pairs of compound names and formulae are correct?
3. Methane CH4
4. Hydrogen peroxide H2O2
5. Sulfuric acid HCℓ
6. Zinc hydroxide Zn(OH)2
	1. I and II only.
	2. II, III and IV only.
	3. I, II and IV only.
	4. I, II, III and IV.
7. Metals are able to conduct electricity because:
	1. The positive metal ions pass charges to each other.
	2. All electrons and the positive metal ions flow around freely.
	3. The valence electrons flow around the metal ions.
	4. All ions are freely moving.

1. Which of the following elements has the highest electronegativity?
	1. O
	2. Li
	3. K
	4. S
2. The decrease in atomic radii across a period in the periodic table is due to the increase in the number of:
	1. neutrons
	2. electrons
	3. protons
	4. shells
3. Element X is likely to form X2+ ion in chemical reactions. This element forms its only chloride by heating X with chlorine gas.

What is the equation for the formation of the chloride of X?

* 1. 2X + Cℓ2 🡪 2XCℓ
	2. X + Cℓ2 🡪 XCℓ2
	3. X + 2Cℓ2 🡪 XCℓ4
	4. X + 3Cℓ2 🡪 XCℓ6
1. Select the most appropriate explanation for why an ionic substance can conduct electricity in aqueous solution but not in the solid state.
	1. In the solid state, the positive and negative ions are fixed within a 3D crystallised lattice that requires a large amount of energy to overcome.
	2. In the solid state, the positive ions and delocalised electrons are in a fixed 3D lattice and cannot move.
	3. In the aqueous solution, the delocalised electrons are no longer in a fixed 3D lattice and are free to move and conduct electricity.
	4. In the aqueous solution, the positive and negative ions are no longer in a fixed 3D lattice and are free to move and conduct electricity.
2. Use the information in the diagram below to calculate ∆H for the reaction.

656 kJ

3 C2H2

Enthalpy (H)

83 kJ

C6H6

Progress time

* 1. + 739 kJ
	2. + 573 kJ
	3. – 573 kJ
	4. – 656 kJ
1. Which statement about change in enthalpy is true?
	1. Heat is given off to the surroundings in endothermic reactions.
	2. Enthalpy is a chemical substance of heat.
	3. Enthalpy is associated with kinetic energy of the reactants.
	4. The sign of ∆H is always positive in endothermic reactions.
2. Combustion of any fuel, by its very nature, is always exothermic. This is because:
	1. the chemical reaction involves the breaking of existing bonds to release energy to the surroundings.
	2. the chemical reaction absorbs heat from the surroundings.
	3. the enthalpy of the products is less than the enthalpy of the reactants.
	4. None of the above.
3. When 3.00 moles of zinc metal reacts with excess hydrochloric acid (HCℓ), how many moles of hydrogen gas is expected to be produced?
	1. 1.50 moles
	2. 2.00 moles
	3. 3.00 moles
	4. 4.50 moles
4. The percentage composition (percentage by mass) of aluminum in aluminum (III) hydroxide is:
	1. 61%
	2. 44%
	3. 35%
	4. 12%
5. For the following **unbalanced** chemical equation:

\_\_ Fe + \_\_ Cℓ2 🡪 \_\_ FeCℓ3

What coefficients would balance the equation?

* 1. 3, 2, 2
	2. 1, 1, 1
	3. 4, 2, 2
	4. 2, 3, 2
1. The formula of hydrated sodium sulfate is Na2SO4∙10H2O. The total number of atoms in one formula unit of this compound is:
	1. 7
	2. 17
	3. 27
	4. 37
2. In two moles of nitrogen monoxide (NO) molecules, there are a total of approximately:
	1. 3.0 x 1023 nitrogen atoms.
	2. 6.0 x 1023 nitrogen atoms.
	3. 1.2 x 1024 nitrogen atoms.
	4. 1.8 x 1024 nitrogen atoms.

1. For the following hydrocarbon (C8H18), how many alkyl groups are there?

 CH3 CH3

 | |

CH3 – CH – CH2 – C – CH3

 |

 CH3

* 1. 2
	2. 3
	3. 4
	4. 5
1. C6H12 is the chemical formula of a/an:
	1. Cycloalkene.
	2. Benzene.
	3. Alkane.
	4. Alkene.

**End of Section One**

**Section Two: Short answer 35% (55 marks)**

This section has **ten (10)** questions. Answer **all** questions. Write your answers in the spaces provided.

When calculating numerical answers, show your working or reasoning clearly. Express numerical answers to the appropriate number of significant figures and include appropriate units where applicable.

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Suggested working time: 50 minutes.

1. **(8 marks)**

Complete the following by giving the name or formula for the following:



|  |  |
| --- | --- |
| **Formula** | **Name** |
| CuNO3 |  |
| CCℓ4 |  |
| Mg3(PO4)2 |  |
|  | Aluminium carbonate |
|  | Dinitrogen trioxide |
|  | Calcium Sulfite |
|  | Iron (III) hydrogenphosphate |
|  | Ammonium ion |

1. **(4 marks)**

Observe the table below:

|  |  |  |  |
| --- | --- | --- | --- |
| **Species** | **Protons** | **Neutrons** | **Electrons** |
| A | 6 | 6 | 6 |
| B | 6 | 8 | 6 |
| C | 6 | 7 | 10 |
| D | 11 | 12 | 10 |
| E | 12 | 12 | 10 |
| F | 8 | 8 | 10 |

Using the table above by writing correct letters into the appropriate boxes below.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Isotopes** |  |  | **Neutral atoms** |  |
| **Anions** |  |  | **Cations** |  |

1. **(3 marks)**

Complete the table by drawing or naming the following hydrocarbons using IUPAC nomenclature.



|  |  |
| --- | --- |
| **Structure** | **IUPAC Name** |
| Cℓ H Cℓ| | |H – C – C – C – H| | |H H H |  |
|  | 1-bromo-2-methylbenzene |
|    Br                   |            CH = C – CH2  |               |       Br             CH3       |  |

1. **(4 marks)**

Consider the following reaction complete the table:

Excess bromine gas reacts with ethene gas.

|  |  |
| --- | --- |
| **Observation** |  |
| **Balanced chemical equation with structural formula****(show all atoms)** |  |
| **Name of organic product** |  |

1. **(4 marks)**

On the axes below, sketch an energy profile diagram for the following reaction. Clearly label the reactants, products, axes, and ∆H. Includes all values.

H2 (g) + Cℓ2 (g) 🡪 2HCℓ (g) ∆H = – 185 kJ mol-1

1. **(9 marks)**

Write balanced **FULL** equations for the following reactions described below. Include the states of matter for all the species. For example, solid copper (II) sulfate as CuSO4 (s).

* 1. Silver nitrate solution is mixed with iron (II) chloride solution to produce solid silver chloride and iron (II) nitrate solution. (2 marks)

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* 1. Solid Aluminium carbonate and a solution of nitric acid react to form a solution of aluminium nitrate, carbon dioxide and water. (2 marks)

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* 1. Carbon dioxide gas is bubbled into limewater (Ca(OH)2) to produce calcium carbonate precipitate and a second product. (2 marks)

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(d) A dilute solution of ethanoic acid reacts with a solution of magnesium hydroxide to form a solution of magnesium ethanoate and water. (2 marks)

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States of matter for of all species (1 mark)

1. **(6 marks)**

Beryllium, Magnesium and Calcium are metals in group 2 of the periodic table. Answer the following questions with explanation using the atomic structure of these elements.

* 1. Explain why these metals are malleable. (2 marks)

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* 1. Describe and explain the trend in first ionisation energy for Beryllium, Magnesium and Calcium. (4 marks)

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1. **(4 marks)**

Carbon dioxide is a colourless gas which occupies 0.04% of our atmosphere. The melting point and the boiling point of carbon dioxide are – 56.6 oC and – 78.5 oC respectively.

Explain why carbon dioxide has a very low melting and boiling point.

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1. **(6 marks)**

Complete the following table.

|  |  |  |
| --- | --- | --- |
| **Species** | **Bonding present****(Covalent moleculer, covalent network, ionic and/or metallic)** | **Electrical conductivity at room temperature****(Yes or no)** |
| Gold |  |  |
| Diamond |  |  |
| SiO2 |  |  |
| NO2 |  |  |
| Marble (CaCO3) |  |  |
| AgNO3 Solution |  |  |

1. **(7 marks)**

The average human requires 120 grams of glucose (C6H12O6) per day.

* 1. Calculate the percentage by mass of carbon in each glucose molecule. (3 marks)

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* 1. How many grams of CO2 (in the photosynthesis reaction) are required for this amount of glucose? The photosynthetic reaction is:

6CO2 + 6H2O 🡪 C6H12O6 + 6 O2

(4 marks)

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**End of Section Two**

**Section Three: Extended answer 40% (65 marks)**

This section contains **four (4)** questions. You must answer **all** questions. Write your answers in the spaces provided below.

Where questions require an explanation and/or description, marks are awarded for the relevant chemical content and also for coherence and clarity of expression. Lists or dot points are unlikely to gain full marks.

Final answers to calculations should be expressed to the appropriate number of significant figures.

Spare pages are included at the end of this booklet. They can be used for planning your responses and/or as additional space if required to continue an answer.

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* Continuing an answer: If you need to use the space to continue an answer, indicate in the original answer space where the answer is continued, i.e. give the page number. Fill in the number of the question(s) that you are continuing to answer at the top of the page.

Suggested working time: 60 minutes.

1. **(13 marks)**

The following simplified diagram shows the path of a 20Ne+ ion through a mass spectrometer.

A

* + 1. What is the name of part A in this mass spectrometer? (1 mark)

 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

* + 1. Why is part A required in this mass spectrometer? (1 mark)

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**Continue Question 36**

* + 1. On the diagram of the mass spectrometer, sketch the path that would be taken by a 21Ne+ ion introduced if it were into the spectrometer at the same time as the 20Ne+ ion shown. (1 mark)
		2. Explain why the paths travelled by the two ions differ. (2 marks)

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The relative abundances of all the neon isotopes in a sample is collected using the mass spectrometer. The result is shown below. Note that m/z value is equivalent to the mass number of a neon ion. (For example, m/z = 20 means 20Ne+ isotope.)

* 1. Use the above graph to calculate the relative atomic mass of neon. (2 marks)

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Atomic absorption spectroscopy (AAS) can be used to distinguish different elements such as neon and helium atoms. The diagram below shows the emission spectra of helium and neon.

* 1. Explain how these spectra lines are produced. (3 marks)

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* 1. The number of lines spectra of helium and neon are different. Give an explanation for this.

(3 marks)

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1. **(15 marks)**

The following table shows the radii of different elements.

|  |  |  |
| --- | --- | --- |
| **Element** | **Atomic Number (Z)** | **Atomic radius** **( x10-12  metres)** |
| O | 8 | 66 |
| F | 9 | 68 |
| Ne | 10 | 67 |
| Na | 11 | 186 |
| Mg | 12 | 160 |
| Al | 13 | 143 |
| Si | 14 | 118 |
| P | 15 | 110 |
| S | 16 | 102 |
| Cl | 17 | 99 |
| Ar | 18 | 95 |

* 1. Graph these results below, by plotting the atomic number on the horizontal axis. If you make a mistake, a spare grid is available at the back of this booklet. (4 marks)

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* + 1. From the graph, describe the trend in the atomic radius that occurs from sodium to argon. (1 mark)

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* + 1. Explain why this trend occurs. (3 marks)

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* 1. Compare the radii of an oxygen atom and sulfur atom. Explain the difference.

(2 marks)

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* 1. Would a chloride ion be bigger or smaller than the chlorine atom? Explain your answer.

(3 marks)

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(e) Describe the changes in electronegativity that would be observed from sodium to argon.

 (2 marks)

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1. **(16 marks)**

When magnesium metal reacts with oxygen from the air, a grey-white solid is formed. This chemical reaction can be performed in a crucible in the science lab.

* 1. Write a balanced chemical equation for this reaction. (2 marks)

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The setup of the combustion reaction is shown below:

A student, Paul, wants to use this experiment to find the mass of oxygen reacting with the magnesium.

* 1. The teacher of the student, Mrs Philips, suggests that the lid of the crucible need to be open slightly during the reaction. Explain the reason for this. (1 mark)

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After the experiment, Paul summarises his result as follows:

Mass of crucible and lid (g) 38.5980 g

Mass of crucible, lid and magnesium (g) 38.7860 g

Mass of crucible, lid and magnesium oxide (g) 38.8873 g

* 1. Use Paul’s results to calculate:

(2 marks)

|  |  |
| --- | --- |
| **Mass of Magnesium (g)** |  |
| **Mass of Magnesium oxide (g)** |  |

* 1. Calculate the number of moles of magnesium at the beginning of the experiment. (2 marks)

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* 1. Calculate the number of moles of magnesium oxide produced at the conclusion of the experiment. (2 marks)

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* 1. Using your equation and answer from part (d), calculate the number of moles of magnesium oxide Paul is **expected** to produce in this experiment. Explain why the expected value is different to part (e). (3 marks)

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* 1. Use the answer from part (d), calculate the theoretical mass of the oxygen gas reacted in this combustion. How does this value compare to the amount which actually reacted? (4 marks)

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1. **(21 marks)**

A fuel is any material that can be made to react with oxygen gas so that it releases energy as heat. Fossil fuels are fuels from natural processes such as anaerobic decomposition of buried dead organisms. One example of a fossil fuel is ethane.

The **unbalanced** chemical equation of the combustion of ethane is shown below:

 C2H6 + O2 🡪 CO2 + H2O

* 1. Balance the chemical equation above using whole numbers. (1 mark)
	2. Draw dot diagram (Lewis structures) for C2H6. Show all valence shell electron pairs as either : or —. (2 marks)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| For example, water |  | or |  | or |  |

|  |  |
| --- | --- |
| C2H6 |  |

The following table shows how much heat energy is required to break each bond of all reactants and the total heat energy required for the reaction. This can be done by referring to the chemical equation in part (a).

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Species** | **Bond within the molecule** | **Number of bonds in each molecule** | **Number of molecules from the equation** | **Energy required to break one bond (kJ/mol)** | **Energy required to break all bonds (kJ/mol)** |
| C2H6 | C – C(single bond) | 1 | 2 | 347 | 1 x 2 x 347 = 694 |
| C – H (single bond) | 6 | 2 | 410 | 6 x 2 x 410 = 4920 |
| O2 | O = O(double bond) | 1  | 7 | 494 | 1 x 7 x 494 = 3458 |
|  |  |  | **Total energy required to break all bonds** | 9072 |

* 1. Use the method in previous page and equation in part (a) to complete the following table.

(4 marks)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Species** | **Bond within the molecule** | **Number of bonds in each molecule** | **Number of molecules from the equation** | **Energy released when forming one bond (kJ/mol)** | **Energy released when forming all bonds (kJ/mol)** |
| CO2 | C = O(double bond) |  |  | 799 |  |
| H2O | H – O(single bond) |  |  | 460 |  |
|  |  |  | **Total energy required to form for all bonds** |  |

* 1. By considering the energy released when new bonds form and the energy required for breaking bonds. Calculate the net energy change. Determine if the reaction is an endothermic or exothermic reaction. (2 marks)

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* + 1. Is the value of ∆H positive or negative? Explain your answer. (2 marks)

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* + 1. Describe a consequence that occurs to the surroundings after this chemical reaction.

 (1 mark)

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1.00 tonne of ethane gas is pumped into a combustion chamber to undergo this combustion reaction. Assume that there is no loss of energy in the reaction. (1 tonne = 1000 kg)

* 1. Calculate the number of moles of ethane reacted. (2 marks)

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* 1. Calculate the mass, in tonnes, of oxygen required in this reaction if the ethane is fully reacted. (4 marks)

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**Continue Question 39**

* 1. Using the answers in parts (d) and (f), calculate the energy produced by combusting of 1.00 tonne of ethane. (3 marks)

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**End of examination.**

**Spare answer page**

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**Spare answer page**

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**Spare answer page**

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**Spare answer page**

**Question number: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

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 **Spare graph**

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**Acknowledgements**

**Question 37** S., M., Goldwasser, Sam’s Laser FAQ [image]. Retrieved November 2016, from http://www.2lss.de/laserfilez/downloads/Misc/laserfaq/laserioi.htm.

**Question 38** The structure of the graphene tube nanotechnology - 3d illustration,iStock Photo [image]. Retrieve December 2016, http://www.istockphoto.com/au/photo/the-structure-of-the-graphene-tube-nanotechnology-3d-illustration-gm542811892-97256529.

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