



# Diagnostic test

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It is assumed that students taking up study of T868 will be familiar with the mathematics and chemistry covered in undergraduate science and engineering courses. To give an idea of the level of mathematics and chemistry assumed, the following questions have been compiled. You may like to attempt them before deciding to register for T868.

## QUESTIONS

### Mathematics

#### Decimals, powers and indices

- 1 What is  $7289/10\,000$  in decimal notation?
- 2 Write down the equivalent of  $100\,000$  as  $10$  raised to some power.
- 3 What are the equivalents of
  - (a)  $0.8$
  - (b)  $1.5$
  - (c)  $0.333$expressed as fractions?
- 4 Express the following in index form:
  - (a)  $\sqrt{10}$
  - (b)  $1/\sqrt{5}$ .
- 5 What are the values of  $\sqrt{16}$ ,  $\sqrt{25}$  and  $\sqrt{225}$ ?

#### Units and physical quantities

- 1 What are the SI units for mass, pressure and energy?
- 2 What are the meanings of the following prefixes?
  - (a) kilo-
  - (b) giga-
  - (c) milli-
- 3 Express each of the following amounts using prefixes:
  - (a)  $1000\text{ g}$
  - (b)  $1\,000\,000\text{ N}$
  - (c)  $10^{-6}\text{ Pa}$ .

#### Mean and median

- 1 What is the median of  $10, 18, 18, 19, 20, 21$  and  $100$ ?
- 2 What is the arithmetic mean of  $1, 2, 3$  and  $7$ ?

## Equations and graphs

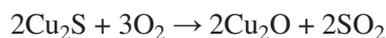
- 1 If  $y = mx + c$ , what will be the form of a graph of  $y$  against  $x$ ?
- 2 If  $\varphi = \pi d^2 u / 4$ , express  $u$  as a function of  $\varphi$  and  $d$ .
- 3 If  $S(1 - A) = 4\sigma T^4$ , find an equation for  $T$ .

## Exponentials and logarithms

- 1 What is  $e$ ?
- 2 What is  $e^{-kt}$  when  $k$  is  $0.3 \text{ d}^{-1}$  and  $t = 7$  days? Give your answer to four decimal places.
- 3 What is  $\ln(2.3)$ ?
- 4 What is  $20 \times \log_{10}(500)$ ?
- 5 What is another way of writing (a)  $e^A \times e^B$  and (b)  $\ln A + \ln B$ ?
- 6 What is  $10 \log_{10}(4\pi r^2)$  if  $r$  has a value of 5?
- 7 Find  $R$  if  $20 \log_{10}(R) = 55$ .

## Chemistry

- 1 Are the following statements true or false?
  - (a) All chemical materials are made up of atoms.
  - (b) All materials are either elements or compounds.
  - (c) Chemical elements are made up of chemical compounds.
  - (d) Chemical reactions always occur when two compounds are mixed together.
  - (e) Chemical reactions always give off heat.
  - (f) A solution is a chemical compound containing water.
  - (g)  $\text{H}_2\text{O}$  is the chemical shorthand for water.
  - (h) An ion is the same as an atom.
  - (i)  $\text{CH}_4 + 3\text{O}_2 \rightarrow \text{CO}_2 + 2\text{H}_2\text{O}$  is a representation of the reaction between natural gas and air, and is a balanced equation.
- 2 In the extraction of copper from the mineral chalcocite ( $\text{Cu}_2\text{S}$ ), sulfur dioxide is produced according to the following equation:



Calculate the amount of sulfur dioxide produced when 1 tonne of  $\text{Cu}_2\text{S}$  is processed, given that the relative atomic masses are  $\text{Cu} = 63.5$ ,  $\text{S} = 32$  and  $\text{O} = 16$ .

# ANSWERS

## Mathematics

### Decimals, powers and indices

- 1 0.7289
- 2  $10^5$
- 3 (a)  $4/5$ ; (b)  $3/2$ ; (c)  $1/3$
- 4 (a)  $10^{1/2}$  or  $10^{0.5}$ ; (b)  $5^{-1/2}$  or  $5^{-0.5}$
- 5  $\pm 4$ ,  $\pm 5$  and  $\pm 15$

### Units and physical quantities

- 1 The units are kilogram (kg), pascal (Pa) (equal to one newton per square metre) and joule (J).
- 2 (a) One thousand, i.e. 1000 or  $10^3$ ; (b) ten to the power 9, i.e.  $10^9$ ; (c) one thousandth, i.e. 0.001 or  $10^{-3}$ .
- 3 (a) 1 kg; (b) 1 MN; (c) 1  $\mu$ Pa

### Mean and median

- 1 19 (this is the middle value of the set)
- 2 3.25

### Equations and graphs

- 1 It will be a straight line with gradient  $m$  and intercept  $c$  on the y-axis ( $x = 0$ ).
- 2  $u = 4\phi / \pi d^2$
- 3  $T = [S(1 - A) / 4\sigma]^{1/4}$

### Exponentials and logarithms

- 1  $e$  is a mathematical constant with a value of 2.718 281 828 (to nine decimal places). It is used in describing exponential growth and decay.
- 2 0.1225
- 3 0.833 (to three decimal places)
- 4 53.979 (to three decimal places)
- 5 (a)  $e^{(A+B)}$ ; (b)  $\ln AB$
- 6 24.971 (to three decimal places)
- 7  $R = 10^{55/20} = 562.34$  (to two decimal places)

## Chemistry

- 1 (a) True. The simplest chemical entity is a single atom. Atoms may be joined to like atoms (as elements) or different atoms (as molecules), and these may be tightly joined together to form a solid. If the molecules are less tightly joined together, they form a liquid, or if not joined at all, they form a gas.
- (b) False. Some materials – such as concrete, wood and some cloth – are mixtures of different elements and compounds. A piece of iron, for example, consists solely of atoms of the element iron. Rust, on the other hand, is a compound of the elements of iron and oxygen. A compound is made up of molecules, each of which is composed of a constant number of atoms of the constituent elements.
- (c) False. Compounds are composed of elements.
- (d) False. Sugar and salt are two simple compounds that do not react when mixed, and can be separated out from one another. When a reaction occurs, the resulting product may also be a mixture, but it is a mixture of different compounds from the starting mixture. This mixture still contains the same elements within the resulting compounds.
- (e) False. Some reactions only occur when heat is supplied to the reactants.
- (f) False. A solution is a mixture of a solid, liquid or gas in a liquid such that the resulting mixture is a uniform liquid composed of loosely coupled atoms and molecules of the original liquid (solvent) and the solid, liquid or gas (solute).
- (g) True. Each element has been given an internationally agreed symbol, such as H for hydrogen and O for oxygen. Since in a given compound such as water the constituent elements are always incorporated in the same proportions, they can be represented by shorthand that uses the appropriate symbols and number of atoms of each element per molecule.
- (h) False. An ion is an atom that has gained or lost one or more electrons (negatively charged particles).
- (i) Partially true.  $\text{CH}_4$  is the chemical shorthand for methane, the major component of natural gas, which reacts with oxygen ( $\text{O}_2$ ) to produce carbon dioxide ( $\text{CO}_2$ ) and water vapour ( $\text{H}_2\text{O}$ ). However, the reaction as shown is not a balanced equation since there are fewer atoms of oxygen in total on the right than on the left. The correct form is:



- 2 From the equation  $2\text{Cu}_2\text{S} + 3\text{O}_2 \rightarrow 2\text{Cu}_2\text{O} + 2\text{SO}_2$ :
- $2[(63.5 \times 2) + 32]$  g of  $\text{Cu}_2\text{S}$  results in  $2[32 + (16 \times 2)]$  g of  $\text{SO}_2$  being produced,  
i.e. 318 g of  $\text{Cu}_2\text{S}$  results in 128 g of  $\text{SO}_2$  being produced.

Therefore 1 tonne of  $\text{Cu}_2\text{S}$  will generate

$$(128 \text{ g} / 318 \text{ g}) \times 1 \text{ tonne of } \text{SO}_2 = 0.40 \text{ tonne of } \text{SO}_2.$$