UNIT 2 ANALYTICAL CHEMISTRY AND ITS TOOLS

A. BRANCHES OF CHEMISTRY

1 *Can you match the branches of chemistry and the subjects they cover before reading the passage* A wide-ranging science?

a. General chemistry	☐	**1.** Application of chemistry to different technologies
b. Inorganic chemistry	☐	**2.** Application of chemistry to manufacturing processes
c. Organic chemistry	☐	**3.** Application of mathematics and physics to chemistry
d. Analytical chemistry	☐	**4.** Chemical processes in living things
e. Physical chemistry	☐	**5.** Compounds of carbon
f. Nuclear chemistry	☐	**6.** Compounds excluding those of carbon
g. Industrial chemistry	☐	**7.** Determination of the composition of substances
h. Applied chemistry	☐	**8.** Molecules and their transformation
i. Biochemistry	☐	**9.** Radioactivity, fission and fusion of nuclei

A WIDE-RANGING SCIENCE

Chemistry is a science concerned with the synthesis, structures, dynamics, properties and transformations of all types of materials – organic, inorganic and biological.
Organic chemistry is a **branch** of chemistry which **embraces** almost all compounds of carbon.
Inorganic chemistry is generally considered to involve all substances except hydrocarbons and their derivatives, or all substances that are not compounds of carbon disulphide.
Organic and inorganic chemistry often **overlap**. For example, chemical bonding **applies** to both disciplines, electrochemistry and acid-base reactions have their organic counterparts, catalysts and coordination compounds may be either organic or inorganic.
Analytical chemistry is the subdivision of chemistry concerned with identification of materials (qualitative analysis) and with determination of the percentage composition of mixtures or the constituents of a pure compound (quantitative analysis). The gravimetric and volumetric (or "wet") methods (precipitation, titration and solvent extraction) are still used for routine work and new titration methods have been introduced. However, faster and more accurate techniques (collectively called instrumental) have been developed in the last decades. ▶

GLOSSARY

to apply: to refer **branch**: part **to embrace**: to include **to overlap**: to coincide

Among these are infrared, ultraviolet, and x-ray spectroscopy, colorimetry, chromatography, separation of mixtures in ion exchange columns and radioactive tracer analysis. Optical and electron microscopy, mass spectrometry, microanalysis, Nuclear Magnetic Resonance (NMR) and Nuclear Quadruple Resonance (NQR) spectroscopy all fall within the area of analytical chemistry. New and highly sophisticated techniques have been introduced in recent years, in many cases **replacing** traditional methods.

Physical chemistry is the application of the concepts and laws of physics to chemical phenomena **in order to** describe in quantitative terms a vast **amount** of qualitative information. **Although** physical chemistry is closely related to both inorganic and organic chemistry, it is considered a separate discipline

Nuclear chemistry is the division of chemistry **dealing with** changes in or transformations of the atomic nucleus. The reactions involving nuclei are usually accompanied by large energy changes that are **carried out** in nuclear reactors for electric power production and **manufacture** of radioactive isotopes for medical use.

Biochemistry is 'the chemistry of life'. It studies the structure and properties of molecules in living organisms and how these molecules are made, changed and broken down.

Organic chemistry is the chemistry of carbon compounds.
Biochemistry is the chemistry of carbon compounds that crawl.

2 Student A: *Using the prompts below, ask questions about the reading passage.* Student B: *answer Student A's questions.*

a. What / chemistry / be concerned with?

b. What substances / organic chemistry / study?

c. What substances / inorganic chemistry / study?

d. The division between organic and inorganic chemistry / be clearly cut?

e. What analyses / analytical chemistry / deal with?

f. What / qualitative analysis and quantitative analysis / consist in?

g. You / some analytical 'wet methods' / can name?

h. What / the advantages of instrumental methods over 'wet' methods / be?

i. You / some instrumental methods / can name?

j. What two sciences / be involved / in physical chemistry?

k. What / nuclear chemistry / deal with?

l. What / biochemistry / study?

GLOSSARY

although: even if
amount: quantity
to carry out: to execute
to deal with (dealt-dealt): to treat
in order to: with the purpose or intention of
manufacture: production
to replace: to substitute

B. ANALYTICAL CHEMISTRY
C. ANALYTICAL METHODS AND INSTRUMENTAL ANALYSIS

3 *In which order are these analytical procedures dealt with in the following passage?*

- ☐ Colorimetric analysis
- ☐ Conductimetric analysis
- ☐ Pressure measurements
- ☐ Titrimetric analysis

ANALYTICAL TECHNIQUES

The rate of a chemical reaction can be obtained by following some property which alters with the extent of the reaction. By analysing the reaction mixture at suitable intervals, it is possible to determine the concentration of both reactants and products at different times and hence obtain a measure of the reaction rate (i.e. the rate at which the concentration of a particular substance changes with time).

The choice of analytical method depends on the reaction under consideration. The following techniques illustrate four possible approaches.

One method is particularly suitable for reactions in solution. The reaction can be followed by removing and analysing small portions of the reaction mixture at intervals. Very often, the removed portion must be added to some reagent which will stop the reaction (i.e. "quench" it), thereby preventing further changes in concentration before the analysis is carried out. The quenched mixture can then be analysed by titrating the substance.

Another method is especially convenient for those systems in which one of the substances is coloured. The intensity of colour can be followed during the reaction using a photoelectric colorimeter, and from these measurements the concentration of the coloured species can be obtained at different times.

Many reactions in aqueous solution involve ions and changes in the number of ions present as the reaction proceeds. Consequently the electrical conductivity of the solution will change during the reaction and this can be used to determine the changing concentrations of reactants and products with time. Essentially, this consists in immersing two inert electrodes in the reaction mixture and then following the change in electrical conductivity of the solution with time.

A fourth technique is particularly suitable for reactions in the gas phase which involve changes in pressure when the system is kept in a vessel of constant volume. The pressure is measured at suitable time intervals.

The last three methods have one great advantage over titrimetric analysis in that samples need not be removed from the reacting mixture. In these three cases, the extent of the reaction is determined at intervals of time by an external method without disturbing the reaction mixture.

It is important to realize that measurements on the reacting system do not give the rate of reaction directly; they simply give the concentration of a particular reactant or product, X, at a given time, t. By plotting a graph of the concentration of X against time, it is possible to determine the reaction rate (i.e. the change in concentration of X with time, d[X]/dt) from the gradient of the tangent at a given point.

(from: Hill-Hollman, *Chemistry in Context*, Nelson)

4 *Answer these questions about* Analytical techniques.

a. How can the rate of a chemical reaction be measured? • **b.** What analytical methods are used to measure reaction rates? • **c.** What reactions is titrimetric analysis most suitable for? • **d.** What apparatus is used in colorimetric analysis? • **e.** How is conductimetric analysis carried out? • **f.** What reactions are pressure measurements most convenient for?