THE ESSENCE OF CHEMISTRY

The essence of chemistry is the study of chemical reactions, the combination of the elements and their compounds to give new compounds. Chemists have used reactions to produce the materials – Teflon, nylon, polystyrene, and PVC, among others – so vital in our modern economy. Cancer chemotherapy agents and experimental drugs to treat AIDS are produced by chemical reactions. Plants and animals are chemical reaction factories.

There are certain principles that govern all chemical reactions. In any chemical change, matter is conserved. Although the atoms involved are re-arranged into different species in the course of a reaction and the number of molecules may change, the total number of atoms of each kind in the reactants and products must be the same. Thus a balanced chemical equation shows the relative amounts of products and reactants.

In combination reactions elements combine (a) with the halogens and (b) with oxygen. Combustion reactions involve the combination of a compound of C and H, or one of C, H, and some other element, to give CO_2, H_2O, and another oxide as appropriate.

In decomposition reactions compounds break down into simpler compounds, usually by heating. The decomposition of metal carbonates to give metal oxides and CO_2 is an example.

Stoichiometry is the study of mass relations in chemical reactions, and its guiding principle is the conservation of matter.

Many important chemical reactions occur in water. Ionic compounds that contain certain ions can dissolve in water to a significant extent. In doing so, they break up or dissociate into their ions. The resulting solution conducts electricity, so the dissolved ionic compounds are called electrolytes.

Some ions do not enter directly into reactions involving ionic compounds and so are called spectator ions.

Since many reactions occur in solution, the concentration of material (the solute) in the reaction medium (the solvent) must be defined. A very convenient unit of concentration is molarity.

A titration is a way to carry out a reaction in a very precise manner and to use it for analysis. In an acid-base titration, acid of known concentration is added to a base of unknown concentration (or vice versa) until the number of moles of H_3O^+ that can be supplied by the acid is exactly equal to the number of moles of OH^- that can be supplied by the base. This is called the equivalence point. From the known stoichiometry of the reaction that occurs, one can find the amount of unknown acid or base.

Oxidation-reduction reactions (often called redox reactions) involve the transfer of electrons between compounds. A compound is said to be reduced if the oxidation number of one of its atoms is reduced by acquiring electrons from another species, the reducing agent. Conversely, a compound is oxidised if the oxidation number of one of its atoms is increased because that compound has transferred one or more electrons to an oxidising agent.

(from: Kotz & Purcel, *Chemistry and Chemical Reactivity*, Hartcourt Brace Jovanovich College Publishers)

1 *Answer these questions about* The essence of Chemistry.

a. When does a chemical reaction occur?
b. What information does a balanced chemical equation provide?
c. What happens to elements in combination reactions?
d. What happens to the substances involved in combustion reactions?
e. What happens to compounds in decomposition reactions?
f. What is stoichiometry?

2 *Using these verbs, join the 'heads'* a-h *and* 'tails' 1-8 *into meaningful sentences:* accepts, are not, are transferred, donates, include, is, to analyse, to measure.

a. Some ions are called 'spectator ions' because they ☐
b. Some fundamental chemical reactions ☐
c. Molarity is very useful ☐
d. Molarity ☐
e. Titration is a procedure used ☐
f. In redox reactions electrons ☐
g. The reducing agent is the substance that ☐
h. The oxidising agent is the substance that ☐

1. a substance by means of a reaction in solution with a reagent of known concentration.
2. between compounds.
3. directly involved in the reaction.
4. electrons.
5. electrons.
6. redox, acid-base and precipitation reactions.
7. the concentration of the solution in the solvent.
8. the number of moles of solute per litre of solution.

3 *Which of the words in brackets is the correct synonym for the words underlined in the following sentences?*

a. Many important chemical reactions occur (*are found* / *take place*) in water.
b. Ionic compounds can dissolve in water to a significant extent (*degree* / *length*).
c. Acids provide H^3O^+ ions in water while (*when* / *whereas*) bases provide OH^- ions.
d. A very convenient (*suitable* / *inexpensive*) unit of concentration is molarity.
e. This allows (*enables* / *gives permission*) us to find the new concentration.
f. A titration is a way to carry out (*transport* / *conduct*) a reaction in a very precise manner.

4 *Decide whether the words underlined in the following passage are* nouns, verbs, adjectives or adverbs *by putting a tick in the correct place in the chart below.*

The rates at which chemical reactions occur are just as important to you as they are to the (1) industrialist and the (2) chemical engineer.
At home you might be interested in the rate at which you can boil an egg or (3) bake a cake. (4) Outdoors you might be interested in the rate at which the car is (5) rusting, or the (6) stone-work of (7) buildings is being weathered by acidic gases in the atmosphere.
In industry, (8) engineers and other workers will be closely concerned with the rates of chemical reactions in industrial processes and in (9) constructional (10) engineering. These might include ▶

the rate at which ammonia can be obtained from nitrogen and hydrogen, the rate at which (11) concrete (12) sets or the rate of growth of a particular fruit or (13) vegetable crop.
Industrialists and chemical engineers are not satisfied with (14) merely turning one substance into another. In most cases, they want to perform reactions and obtain products rapidly, easily and as cheaply as possible. Time and money are important in industry, and it is often necessary to accelerate reactions so that they are economically (15) worthwhile.
Reaction rates are also of (16) archaeological importance. Archaeologists can (17) estimate the age of rocks, fossils or prehistoric (18) remains by a process known as radio-active (19) dating in which they measure the concentration of a (20) decaying radioactive isotope such as 14C in the object under scrutiny.

WORD	NOUN	VERB	ADJ.	ADV.
1. industrialist				
2. chemical				
3. bake				
4. outdoors				
5. rusting				
6. stone-work				
7. buildings				
8. engineers				
9. constructional				
10. engineering				
11. concrete				
12. sets				
13. vegetable				
14. merely				
15. worthwhile				
16. rely				
17. archaeological				
18. estimate				
19. remains				
20. dating				
21. decaying				