Coimisiún na Scrúduithe Stáit
State Examinations Commission

Leaving Certificate 2024

Marking Scheme

Chemistry

Ordinary Level

Note to teachers and students on the use of published marking schemes

Marking schemes published by the State Examinations Commission are not intended to be standalone documents. They are an essential resource for examiners who receive training in the correct interpretation and application of the scheme. This training involves, among other things, marking samples of student work and discussing the marks awarded, so as to clarify the correct application of the scheme. The work of examiners is subsequently monitored by Advising Examiners to ensure consistent and accurate application of the marking scheme. This process is overseen by the Chief Examiner, usually assisted by a Chief Advising Examiner. The Chief Examiner is the final authority regarding whether or not the marking scheme has been correctly applied to any piece of candidate work.

Marking schemes are working documents. While a draft marking scheme is prepared in advance of the examination, the scheme is not finalised until examiners have applied it to candidates' work and the feedback from all examiners has been collated and considered in light of the full range of responses of candidates, the overall level of difficulty of the examination and the need to maintain consistency in standards from year to year. This published document contains the finalised scheme, as it was applied to all candidates' work.

In the case of marking schemes that include model solutions or answers, it should be noted that these are not intended to be exhaustive. Variations and alternatives may also be acceptable. Examiners must consider all answers on their merits, and will have consulted with their Advising Examiners when in doubt.

Future Marking Schemes

Assumptions about future marking schemes on the basis of past schemes should be avoided. While the underlying assessment principles remain the same, the details of the marking of a particular type of question may change in the context of the contribution of that question to the overall examination in a given year. The Chief Examiner in any given year has the responsibility to determine how best to ensure the fair and accurate assessment of candidates' work and to ensure consistency in the standard of the assessment from year to year. Accordingly, aspects of the structure, detail and application of the marking scheme for a particular examination are subject to change from one year to the next without notice.

In considering this marking scheme for the written examination, the following points should be noted.

1. In many instances only key words are given – words that must appear in the correct context in the candidate's answer in order to merit the assigned marks.
Where incorrect terminology is used or where part of the candidate's answer contradicts another part, the marks may not be awarded. Cancellation may apply when a candidate gives more than the required number of responses, or a list of correct and incorrect answers.

2. Words, expressions or statements separated by a solidus, /, are alternatives which are equally acceptable.

3. A double solidus, //, separates answers which are mutually exclusive. A partial answer from one side of the // may not be taken in conjunction with a partial answer from the other side.

4. The descriptions, methods and definitions in the scheme are not exhaustive and alternative valid answers are acceptable.

5. The detail required in any answer is determined by the context and manner in which the question is asked, and also by the number of marks assigned to the answer in the examination paper. Therefore, in any instance, it may vary from year to year.
Material that is bracketed is not required in that year.

6. When a candidate is asked to identify a chemical substance, either the name or formula is accepted, unless otherwise indicated. For *deionised water*, the term *distilled water* or *pure water* should also be accepted, unless otherwise indicated. Inorganic compounds may be named using oxidation state or traditional naming convention – e.g. potassium manganate(VII) or potassium permanganate for $KMnO_4$.

7. Each time an arithmetical error occurs in a calculation, one mark is deducted; this also applies to inappropriate or incorrect rounding of numerical answers. This deduction applies to incorrect M_r values, but only if a candidate shows the addition of all the correct atomic masses and the error is clearly an arithmetical one. If the addition of atomic masses is not shown, the candidate loses the marks for an incorrect M_r.

8. For drawing the molecular structure of an organic compound, one mark is deducted if the H atoms are omitted in a systematic way and one mark is deducted if bonds to H atoms are omitted in a systematic way.

9. A zero should only be recorded when the candidate has attempted the question item but does not merit marks. If a candidate does not attempt a question item examiners should record NR.

10. Examiners are expected to annotate each part of the candidate's response as directed at the marking conference.

For a fully correct response, examiners may award one total mark (e.g. 6 marks) or a number of partial marks (e.g. 2 marks, 2 marks, 2 marks) that add to the same total.

For an incorrect or partially incorrect response, examiners should place the appropriate annotations near the correct/incorrect elements of the response such that a total mark is generated for the response (e.g. 2 marks, 0 marks, 2 marks).

Symbol	Name	Use
	Cross	Incorrect element
	Tick	Correct element (0 marks)
	Tick_n	Correct element (n marks)
	Horizontal wavy line	To be noticed
	Vertical wavy line	Additional page
-1	−1	−1
0	0	0 marks
^	^	Missing element
[	Square bracket	Surplus element

11. Bonus marks at the rate of 10% of the marks obtained will be given to a candidate who answers entirely through Irish and who obtains 75% or less of the total mark available (i.e. 300 marks or less). In calculating the bonus to be applied decimals are always rounded down, not up ¬ e.g., 4.5 becomes 4; 4.9 becomes 4, etc. See below for when a candidate is awarded more than 300 marks.

Marcanna Breise as ucht freagairt trí Ghaeilge

Léiríonn an tábla thíos an méid marcanna breise ba chóir a bhronnadh ar iarrthóirí a ghnóthaíonn níos mó ná 75% d'iomlán na marcanna.

N.B. Ba chóir marcanna de réir an ghnáthráta a bhronnadh ar iarrthóirí nach ngnóthaíonn níos mó ná 75% d'iomlán na marcanna don scrúdú. Ba chóir freisin an marc bónais sin **a shlánú síos**.

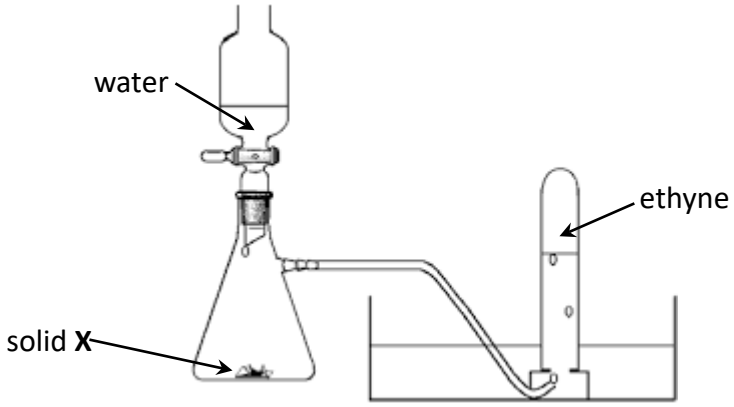
Tábla 400 @ 10%
Bain úsáid as an tábla seo i gcás na n-ábhar a bhfuil 400 marc san iomlán ag gabháil leo agus inarb é 10% gnáthráta an bhónais.

Bain úsáid as an ngnáthráta i gcás 300 marc agus faoina bhun sin. Os cionn an mharc sin, féach an tábla thíos.

Bunmharc	Marc Bónais
301 - 303	29
304 - 306	28
307 - 310	27
311 - 313	26
314 - 316	25
317 - 320	24
321 - 323	23
324 - 326	22
327 - 330	21
331 - 333	20
334 - 336	19
337 - 340	18
341 - 343	17
344 - 346	16
347 – 350	15

Bunmharc	Marc Bónais
351 - 353	14
354 - 356	13
357 - 360	12
361 - 363	11
364 - 366	10
367 - 370	9
371 - 373	8
374 - 376	7
377 - 380	6
381 - 383	5
384 - 386	4
387 - 390	3
391 - 393	2
394 - 396	1
397 - 400	0

1. The diagram below shows the apparatus used for the preparation of ethyne (C_2H_2) gas in the laboratory.



(*a*) Ethyne is an unsaturated hydrocarbon.

(*i*) In organic chemistry, what is meant by unsaturation?

double bond / triple bond / can undergo addition reaction **(4)**

(*ii*) What is a hydrocarbon?

compound containing carbon **(4)**

and hydrogen (only) **(4)**

(*b*) (*i*) Identify solid X.

(calcium) carbide

(*ii*) Why is water added dropwise rather than poured directly onto X?

so that the reaction happens slowly / safety ***[state/imply]***

(*iii*) What is observed when water is added to X?

fizzing / bubbling / gas produced / heat produced

(*iv*) State one property of ethyne that allows it to be collected above water as shown.

less dense than water / sparingly soluble in water **(8 + 8 + 3 + 3)**

(*c*) (*i*) Describe what would be observed when a sample of ethyne is burned in air.

sooty / orange / yellow

flame **(4 + 2)**

(*ii*) Write a balanced chemical equation for the combustion of ethyne in oxygen (O_2).

$2C_2H_2 + 5O_2 \rightarrow 4CO_2 + 2H_2O$ **// $C_2H_2 + 2½O_2 \rightarrow 2CO_2 + H_2O$** **(4 × 1 + 2)**

(*iii*) State one use for ethyne.

e.g. welding, ripening fruit etc. **(4)**

2. The concentration of hydrochloric acid (HCl) was found by titrating it against a 0.05 M solution of sodium carbonate (Na_2CO_3).


A

(*a*) The piece of apparatus labelled A was used to transfer exactly 25 cm^3 of Na_2CO_3 to a conical flask.

(*i*) Identify A.

pipette **(3)**

(*ii*) Describe the procedure used to wash and fill A and to use it to transfer 25 cm^3 of Na_2CO_3 to the conical flask.

wash with deionised water / use a wash bottle

wash with solution

use a pipette filler

draw solution above mark

(reduce volume until the bottom of the meniscus is) level with the mark

allow to fall into flask

tip drop off edge

wash down sides of flask ***[any three]*** **(8 + 3 + 3)**

An indicator was used to identify the endpoint of this titration.

(*b*) (*i*) What is meant by the term endpoint?

neutralisation has occurred / reaction has finished / colour change **(3)**

(*ii*) Name an indicator suitable for use in this titration.

methyl orange **(3)**

(*iii*) State the colour change observed.

yellow / orange **(3)**

to pink / peach / red **(3)**

(*iv*) State two precautions that should be taken to ensure an accurate result.

read at eye level, wash down walls of flask, rough titration,

only use a few drops of indicator, swirling ***[any two]*** **(4 + 2)**

The titration reaction is described by the following balanced chemical equation:

$$Na_2CO_3 + 2HCl \rightarrow 2NaCl + H_2O + CO_2$$

One approximate titration and two accurate titrations were carried out.
The results are shown in the table below.

Approximate titration	First accurate titration	Second accurate titration
20.9 cm^3	20.6 cm^3	20.5 cm^3

(*c*) (*i*) Calculate the average volume of HCl needed to neutralise the Na_2CO_3.

adding volumes **(3)**

20.55 (cm^3) **(3)**

(*ii*) Calculate the concentration of HCl in moles per litre.

$\frac{20.55 \times M}{2}$ **(3)**

$\frac{25 \times 0.05}{1}$ ***[award 3 marks for (implied) formula if no other marks awarded]*** **(3)**

0.12 M **(3)**

3. A student was given unlabelled samples of lithium chloride (LiCl), sodium chloride (NaCl) and potassium chloride (KCl).

(*a*) To identify the samples, the student carried out flame tests.

(*i*) Describe how the flame tests could have been carried out.

Bunsen burner

(platinum) wire / wooden splint

put wire in flame (to clean) / put in water or acid (to clean) / clean

dip into compound

place in flame ***[any three]*** **(9 + 3 + 3)**

(*ii*) State the colour of the flame observed for each salt.

crimson/red, yellow/orange, lilac/purple **(6 + 2 + 2)**

(*b*) The student was given another set of samples of three different unknown compounds. The compounds were on clock glasses labelled A, B and C. The compounds were sodium chloride (NaCl), sodium sulfate (Na_2SO_4) and sodium carbonate (Na_2CO_3).
When a sample of compound A was mixed with dilute hydrochloric acid (HCl) fizzing was observed. The gas produced turned limewater milky.

(*i*) Draw a labelled diagram to show how the gas produced could have been tested with limewater.

delivery (tube from reaction container)

liquid (limewater) in a container

mouth of tube under the surface of the liquid **(4 + 4 + 1)**

(*ii*) Identify the gas produced.

carbon dioxide

(*iii*) Identify compound A.

sodium carbonate

When a sample of compound B was dissolved in water and mixed with a solution of barium chloride ($BaCl_2$) a white precipitate was produced.

(*iv*) Identify compound B.

sodium sulfate

(*v*) Identify a reagent which could be used to confirm that compound C contained chloride (Cl^-) ions.

silver nitrate **(8 + 4 + 2 + 2)**

4. ***Eight items to be answered. Six marks to be allocated to each item and one additional mark to be added to each of the first two items attempted.***

(*a*) A cup of coffee contains 0.095 g of caffeine ($C_8H_{10}N_4O_2$). Calculate the number of moles of caffeine in this cup.

M_r = 194

0.00049 (moles) **(4 + 2)**

(*b*) What is an ionic bond?

force (of attraction)

between (oppositely charged) ions **(4 + 2)**

(*c*) What are isotopes?

same atomic number / same number of protons / same nuclear charge / same element

different mass numbers / different number of neutrons **(4 + 2)**

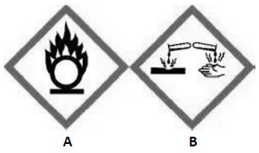
(*d*) Name a piece of apparatus used to measure the heat of combustion of a compound.

(bomb) calorimeter ***[allow 3 marks for e.g. thermometer]*** **(6)**

(*e*) Write a balanced chemical equation for the reaction of magnesium hydroxide ($Mg(OH)_2$) with hydrochloric acid to produce magnesium chloride ($MgCl_2$) and water.

$Mg(OH)_2 + 2HCl \rightarrow MgCl_2 + 2H_2O$ **(4 × 1 + 2)**

(*f*) A chemical container had the warning symbols labelled A and B on it.



(*i*) State the chemical hazard indicated by symbol A.

oxidising

(*ii*) State the chemical hazard indicated by symbol B.

corrosive **(4 + 2)**

(*g*) Identify the carboxylic acid found in the stings of nettles and ants.

methanoic acid / formic acid ***[allow 3 marks for incorrect carboxylic acid]*** **(6)**

(*h*) Describe what happens during the primary stage of sewage treatment.

screening / sedimentation / settling **(6)**

[allow 3 marks for any stage of sewage/water treatment]

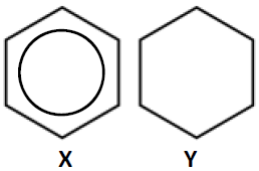
(*i*) When a small amount of air freshener is sprayed in a room it is soon detected in all parts of the room. Explain why this occurs.

diffusion / gaseous **(6)**

(*j*) Define oxidation in terms of electron transfer.

loss **(6)**

(*k*) Molecular structures X and Y both represent cyclic hydrocarbons that contain six carbon atoms.



Which of these hydrocarbons is an aromatic compound?

X **(6)**

(*l*) A Explain the term "continuous process" in industrial chemistry.

process never stops **(6)**

B Name the scientist pictured who used X-ray crystallography to determine the structure of vitamin B12.

Hodgkin **(6)**

5. The periodic table on page 81 of the *Formulae and Tables* booklet shows the electronegativity values of the elements. Part of this table is shown in the diagram below.

1												13	14	15	16	17	18
1 H 2.20	2																2 He – –
3 Li 0.98	4 Be 1.57											5 B 2.04	6 C 2.55	7 N 3.04	8 O 3.44	9 F 3.98	10 Ne – –
11 Na 0.93	12 Mg 1.31	3	4	5	6	7	8	9	10	11	12	13 Al 1.61	14 Si 1.90	15 P 2.19	16 S 2.58	17 Cl 3.16	18 Ar – –
19 K 0.82	20 Ca 1.00	21 Sc 1.36	22 Ti 1.54	23 V 1.63	24 Cr 1.66	25 Mn 1.55	26 Fe 1.83	27 Co 1.88	28 Ni 1.91	29 Cu 1.90	30 Zn 1.65	31 Ga 1.81	32 Ge 2.01	33 As 2.18	34 Se 2.55	35 Br 2.96	36 Kr – –

Electronegativity values increase across a period of the periodic table.

(*a*) (*i*) What is meant by the term electronegativity?

(relative) attraction

for shared electrons / for pair of electrons / for electrons in a bond

(*ii*) Explain why electronegativity values increase across a period.

increasing nuclear charge / decreasing atomic radius

(*iii*) Describe the trend in electronegativity values down a group.

Explain why this trend occurs.

decrease

increasing atomic radius / screening effect (of inner electrons) **(9 + 6 + 3 + 2 + 2)**

(*b*) Nitrogen trifluoride (NF_3) is a greenhouse gas.

(*i*) Name another greenhouse gas.

carbon dioxide, water, methane, nitrous oxide, ozone, CFCs, HCFCs, etc.

[accept formula]

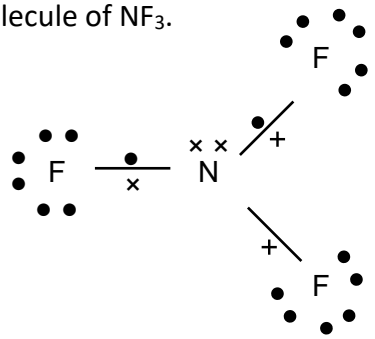
(*ii*) Write the electron configuration for an atom of nitrogen (N).

$1s^2, 2s^2, 2p^3$ / 2, 5

(*iii*) Write the electron configuration for an atom of fluorine (F).

$1s^2, 2s^2, 2p^5$ / 2, 7

(*iv*) Draw a dot and cross diagram to show the arrangement of the valence electrons in a molecule of NF_3.



(*v*) Use the table shown above to calculate the electronegativity difference between N and F.

3.98 – 3.04 = 0.94

(*vi*) Use your answer to (*v*) to predict the type of bonding between the fluorine atoms and the nitrogen atom in NF_3.

polar / polar covalent ***[accept covalent]***

(*vii*) Suggest a possible shape for a molecule containing 4 atoms, such as NF_3.

pyramidal ***[accept tetrahedral/triangular/trigonal]***

(9 + 6 + 4 + 3 + 2 + 2 +2)

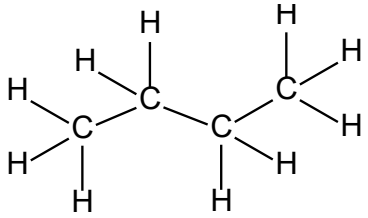
6. (*a*) Liquefied petroleum gas (LPG) is a fuel for some heating and cooking appliances. Isomers with the molecular formula C_4H_{10} are present in LPG.

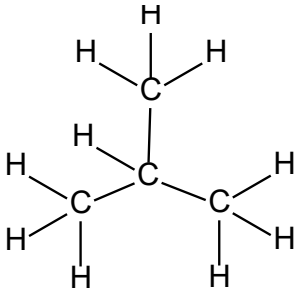
(*i*) What are isomers?

same molecular formulae

different structures **(4 + 2)**

(*ii*) Draw the molecular structure of each of the two isomers with the molecular formula C_4H_{10}, including all atoms and bonds.





[allow maximum marks of 3 + 3 for expanded molecular formulae] **(7 + 2)**

(*iii*) For each of the structures you drew in (*ii*), state the systematic IUPAC name of the isomer.

butane **methylpropane**

(*iv*) Identify a component of LPG which does not have the molecular formula C_4H_{10}.

propane

(*v*) Identify the sulfur-containing compounds which may be added to give LPG an unpleasant smell, warning of leaks.

mercaptans / thiols **(4 + 2 + 2 + 2)**

(*b*) E10 petrol is a fuel containing up to 10% bioethanol. In 2023, E10 petrol replaced E5 petrol in Ireland. E10 petrol and E5 petrol have different octane numbers.

(*i*) What is meant by the term octane number?

measure of a fuels tendency to resist/cause

auto-ignition / knocking

(*ii*) State two ways of increasing the octane number of a fuel.

isomerisation, catalytic cracking, dehydrocylisation,

adding oxygenates, adding lead (compounds) ***[any two]***

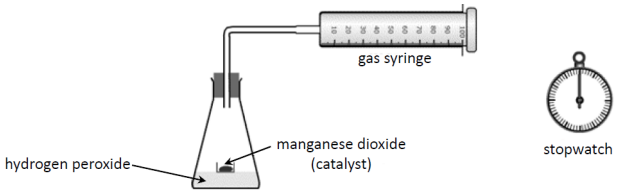
(*iii*) Explain the significance of the compounds heptane and 2,2,4-trimethylpentane in relation to octane number.

reference compounds / octane numbers of 0 and 100

(*iv*) Petrol is obtained by the fractional distillation of crude oil. State one property that the molecules in the petrol fraction have in common with each other.

boiling point (range) / mass / size / number of atoms **(9 + 6 + 3 + 3 + 2 + 2)**

7. The rate of decomposition of hydrogen peroxide (H_2O_2) using manganese dioxide as a catalyst was investigated using the apparatus shown below. The oxygen (O_2) gas produced was collected in the gas syringe.



The results are shown in the table below.

Time (minutes)	0	2	4	6	8	10	12	14	16	18
Volume of O_2 (cm^3)	0	29	48	63	73	81	87	90	92	92

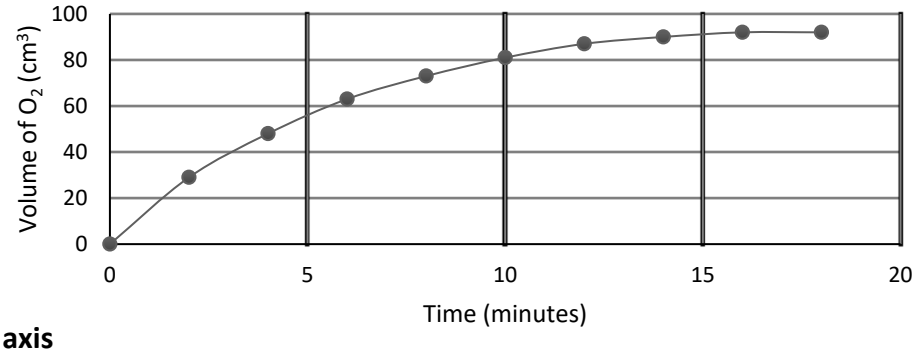
(*a*) (*i*) Define rate of reaction.

change of concentration **(3)**

with respect to time **(3)**

[allow 3 marks for reference to speed]

(*ii*) Draw a graph on graph paper to show how the volume of O_2 produced varies with time.



labelled axis **(3)**

scaled axes **(3)**

points plotted ***[maximum of 3 × 1 if graph paper not used]*** **(6 × 1)**

curve of best fit **(3)**

(*iii*) Use your graph to estimate the volume of oxygen collected during the first 7 minutes.

volume read from graph ***[≈ 68 cm^3]*** **(3)**

(*iv*) Calculate the average rate of reaction during the first 4 minutes.

48 ÷ 4 = 12 (cm^3 $minute^{-1}$) **(3)**

(*b*) (*i*) Explain why the reaction slows down as it proceeds.

reactant / hydrogen peroxide

decreases concentration / used up **(4 + 2)**

(*ii*) The results in the table above were obtained using a fine powder of manganese dioxide. How might the rate of reaction be different if the same mass of manganese dioxide was used but in the form of large pellets? Explain your answer.

rate decreases

smaller surface area (of catalyst) **(6 + 2)**

(*c*) Liver contains an enzyme which can decompose hydrogen peroxide.

(*i*) What is an enzyme?

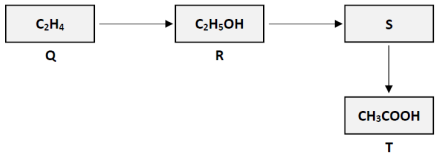
biological **(3)**

catalyst **(3)**

(*ii*) Name an enzyme.

e.g. catalase **(3)**

8. Study the series of reactions shown below and answer the following questions.



(*a*) (*i*) Compound Q is ethene. Name the homologous series to which compound Q belongs.

alkene

(*ii*) Name compound R.

ethanol / ethyl alcohol

(*iii*) Name compound T.

ethanoic acid / acetic acid

(*iv*) Is the conversion of compound Q to compound R classified as an addition reaction, a substitution reaction or an elimination reaction?

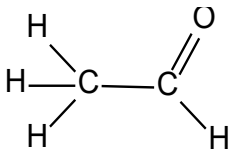
addition **(8 + 6 + 2 + 2)**

(*b*) Compound S is an aldehyde. It reacts with Fehling's reagent to produce compound T.

(*i*) Identify compound S.

ethanal / acetaldehyde **(6)**

(*ii*) Draw the molecular structure of compound S, including all atoms and bonds.



(6)

[allow 3 marks for CH_3CHO]

(*iii*) Describe the colour change that occurs when compound S reacts with Fehling's reagent.

blue **(3)**

to red **(3)**

(*iv*) Identify the metal element in Fehling's reagent which is responsible for the colour change observed.

copper **(3)**

(*c*) A gas is produced when a clean piece of magnesium (Mg) ribbon is added to a test tube containing a solution of compound T.

(*i*) Name the gas produced.

hydrogen / H / H_2

(*ii*) What is observed when a lighted taper is held at the mouth of the test tube?

burns

with a pop **(6 + 3 + 2)**

9. (*a*) (*i*) What is a strong base?

good tendency to // fully dissociates (in water) **(3)**

accept H^+ // to produce OH^- **(3)**

(*ii*) When a strong base reacts with a strong acid, a neutralisation reaction occurs. Would you expect heat to be absorbed or released during neutralisation?

released **(3)**

(*b*) A neutralisation reaction occurs between 0.01 M hydrochloric acid (HCl) and a 0.01 M solution of sodium hydroxide (NaOH).

(*i*) Define pH.

$-\log_{10}$

$[H^+]$

(*ii*) Calculate the pH of the HCl.

$-\log_{10}[0.01]$

= 2

(*iii*) Calculate the pH of the NaOH solution.

$14 + \log_{10}[0.01] = 12$

(*iv*) Outline one limitation of the pH scale.

only works for aqueous solutions / not useful for very concentrated solutions

(6 + 4 + 2 + 2 + 2 + 2)

(*c*) The following terms are omitted from the table below which describes the stages of water treatment.

chlorination filtration flocculation Fluoridation

pH adjustment sedimentation Screening

In your answerbook, write the term corresponding to each of the letters A to G.

Stage	Description
Stage A	Water is passed through a wire mesh to remove any floating debris.
Stage B	Chemicals are added to the water to help small suspended solids clump together.
Stage C	Suspended solids are allowed to settle to the bottom of large tanks.
Stage D	Water is passed through beds of sand to remove suspended solids.
Stage E	Harmful micro-organisms in the water are killed.
Stage F	Chemicals are added to the water which can help strengthen teeth.
Stage G	Small amounts of acid or base are added to the water.

A: screening

B: flocculation

C sedimentation

D filtration

E chlorination

F fluoridation

G pH adjustment **(9 + 4 + 5 × 2)**

10. (*a*) Multistriatin is an organic compound released by the female elm bark beetle when she has found a good source of food.

(*i*) Explain the underlined term.

carbon-containing / natural **(4)**

Following analysis, a sample of multistriatin was found to contain 70.59 % carbon, 10.59 % hydrogen and 18.82 % oxygen by mass.

(*ii*) Calculate the empirical formula of multistriatin.

C: $\frac{70.59}{12} = 5.88$ **(3)**

H: $\frac{10.59}{1} = 10.59$ **(3)**

O: $\frac{18.82}{16} = 1.18$ **(3)**

5:9:1 / C_5H_9O **(3)**

(*iii*) Multistriatin has a relative molecular mass of 170. Calculate its molecular formula.

5 × 12 + 9 × 1 + 1 × 16 = 85 **(2)**

170 ÷ 85 = 2 **(2)**

10:18:2 / $C_{10}H_{18}O_2$ **(2)**

(*iv*) Identify a chemical compound that has the same molecular formula as its empirical formula.

e.g. H_2O **(3)**

10. (*b*) Consider the equilibrium described by the following balanced chemical equation:

$$2NO_{2(g)} \rightleftharpoons N_2O_{4(g)} \qquad \Delta H = -57.2 \text{ kJ mol}^{-1}$$

Nitrogen dioxide (NO_2) has a dark brown colour. Dinitrogen tetroxide (N_2O_4) is colourless.

(*i*) Write the equilibrium constant (K_c) expression for this equilibrium.

$\frac{[N_2O_4]}{[NO_2]^2}$ ***[allow 4 marks if order is reversed]*** **(7)**

A mixture of NO_2 and N_2O_4 is allowed to reach equilibrium.
The mixture has a light brown colour.

(*ii*) What would be observed in the equilibrium mixture if the temperature was increased? Justify your answer.

darker brown colour

endothermic reaction favoured / reverse reaction favoured **(7 + 2)**

(*iii*) What would be observed in the equilibrium mixture if the pressure was increased? Justify your answer.

paler brown colour

reaction with fewer moles/molecules (of gas) favoured **(7 + 2)**

10. (*c*) In Ireland, high levels of radon–222 ($^{222}_{86}Rn$) are found in areas such as Galway and Wicklow, which have a lot of granite rock.
Radon–222 is the most stable isotope of radon, with a half-life of approximately 3.8 days.
It decays by emitting an alpha particle.

(*i*) Explain the underlined term.

time taken

for half a sample to decay / for activity to half **(4 + 2)**

(*ii*) How many protons are present in an atom of $^{222}_{86}Rn$?

86

(*iii*) How many neutrons are present in an atom of $^{222}_{86}Rn$?

222 – 86 = 136

(*iv*) How many electrons are present in a neutral atom of $^{222}_{86}Rn$?

86 **(8 + 2 + 2)**

(*v*) What is an alpha particle?

helium **// two protons** **(2)**

nucleus **// two neutrons** **(2)**

(*vi*) State one property of an alpha particle.

(positively) charged, mass = 4, low penetrating power, highly ionising **(3)**

11. (*a*) (*i*) Name the British scientist who proposed a model of the atom as a sphere of positive charge with electrons embedded in it, also known as the plum pudding model.

Thomson

(*ii*) Name the New Zealand scientist who proposed that an atom is mainly empty space with a dense nucleus at the centre, following his experiments using gold foil.

Rutherford

(*iii*) Name the Russian scientist who proposed the periodic law and produced a periodic table of elements.

Mendeleev **(9 + 3 + 3)**

(*iv*) Describe how the elements are ordered in the modern periodic table.

atomic number

(*v*) The elements of group 1 of the periodic table are called the alkali metals and include lithium (Li), sodium (Na) and potassium (K).
State one property that these elements have in common.

soft, reactive (with air or water), stored under oil, one outer electron, etc.

(*vi*) The elements of group 18 of the periodic table are called the noble gases and include helium (He), neon (Ne) and argon (Ar).
Describe what is common to the electronic structure of these elements.

full outer sublevel ***[accept full outer shell]*** **(6 + 2 + 2)**

11. (*b*) (*i*) Name the Irish scientist who proposed the law describing the relationship between the pressure (*P*) and volume (*V*) of a fixed mass of gas at constant temperature (*T*).

Boyle

(*ii*) Name the French scientist who proposed the law describing the relationship between the volume (*V*) and temperature (*T*) of a fixed mass of gas at constant pressure (*P*).

Charles **(9 + 3)**

(*iii*) Write the equation for the combined gas law.

$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$ ***[accept PV=nRT]*** **(6)**

[accept equation for Boyle/Charles law for 3 marks]

(*iv*) A sample of a gas was found to occupy a volume of 253 cm^3 at a temperature of 300 K and a pressure of 95 kPa. Calculate the volume that the gas would occupy at a temperature of 350 K and a pressure of 105 kPa.

$\frac{95 \times 253}{300} = \frac{105 \times V_2}{350}$

267 (cm^3) **(5 + 2)**

11. (*c*) (*i*) Explain what is meant by the term chromatography.

separation (technique)

using a mobile phase and a stationary phase **(6 + 3)**

(*ii*) Describe how chromatography could be used to separate a mixture of chemical indicators. (A labelled diagram may help your answer.)

mobile phase, e.g. water **(3)**

stationary phase, e.g. filter paper **(3)**

(separated/unseparated) mixture in correct location **(3)**

(*iii*) HPLC is an advanced instrumental method of separation which uses chromatography. What is meant by HPLC?

high performance/pressure liquid chromatography **(4 × 1)**

(*iv*) Name one other instrumental method of separation or analysis.

e.g. distillation **(3)**

11. (*d*) A (*i*) Name a chemical industry which you have studied.

named industry **(3)**

(*ii*) Identify the raw materials used for this industry.

appropriate raw materials **(6)**

(*iii*) Describe the quality control processes for this industry.

description of quality control, e.g. analytical technique(s) **(6)**

(*iv*) Describe any one safety issue for this industry.

e.g. high temperature, high pressure, hazardous materials, etc. **(6)**

(*v*) State one factor taken into account when choosing a location for this industry.

e.g. transport, workforce, etc. **(4)**

11. (*d*) B (*i*) State two differences between metals and non-metals.

metals: conduct heat, conduct electricity, lustrous, malleable, high melting point, high boiling point ***[any two]*** **(6 + 2)**

(*ii*) What is an alloy?

mixture

involving metal(s) **(4 + 2)**

(*iii*) State one example of an alloy.

e.g. steel / nichrome / brass / bronze / alnico, etc. **(4)**

(*iv*) State the composition of the alloy you have named.

Fe + C / Ni + Cr / Cu + Zn / Cu + Sn / Fe + Al + Ni + Co, etc. **(2 + 2)**

(*v*) Suggest a reason why alloys can be more useful than pure metals.

less corrosive, less reactive, stronger, harder, etc. **(3)**