



UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Ordinary Level

CANDIDATE
NAME

CENTRE
NUMBER

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CANDIDATE
NUMBER

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CHEMISTRY

5070/21

Paper 2 Theory

May/June 2011

1 hour 30 minutes

Candidates answer on the Question Paper.

No additional materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.

Write in dark blue or black pen.

You may use a soft pencil for any diagrams, graphs or rough working.

Do not use staples, paper clips, highlighters, glue or correction fluid.

DO **NOT** WRITE IN ANY BARCODES.

Section A

Answer **all** questions.

Write your answers in the spaces provided in the Question Paper.

Section B

Answer any **three** questions.

Write your answers in the spaces provided in the Question Paper.

A copy of the Periodic Table is printed on page 20.

At the end of the examination, fasten all your work securely together.

The number of marks is given in brackets [] at the end of each question or part question.

For Examiner's Use	
Section A	
B6	
B7	
B8	
B9	
Total	

This document consists of **17** printed pages and **3** blank pages.



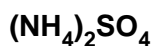
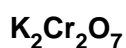
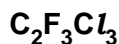
Section A

Answer **all** the questions in this section in the spaces provided.

The total mark for this section is 45.

For
Examiner's
Use

A1 Choose from the following formulae to answer the questions below.



Each formula can be used once, more than once, or not at all.

Which is the formula of a compound that

(a) is a catalyst in the Contact process,

.....[1]

(b) in aqueous solution reacts with aqueous sodium hydroxide to give a white precipitate that redissolves in excess sodium hydroxide,

.....[1]

(c) is an insoluble salt,

.....[1]

(d) is involved in ozone depletion in the upper atmosphere,

.....[1]

(e) in aqueous solution will react with aqueous barium chloride to make a white precipitate,

.....[1]

(f) is an alkane,

.....[1]

(g) is used as a fertiliser?

.....[1]

[Total: 7]

A2 Small pieces of copper were added to excess concentrated sulfuric acid and the mixture heated for 30 minutes. A colourless gas **Z** was formed. When **Z** was tested with filter paper dipped into acidified potassium dichromate(VI), there was a colour change from orange to green.

For
Examiner's
Use

The reaction mixture was cooled and then diluted with water. A blue solution, **Y**, was formed. Aqueous sodium hydroxide was added drop by drop to the blue solution. Eventually a blue precipitate, **X**, was formed. On heating the blue precipitate turned black to form compound **V**. Analysis of **V** showed that it contained 79.9 % copper and 20.1 % oxygen by mass.

(a) Name gas **Z**.

.....[1]

(b) Name the blue solution **Y**.

.....[1]

(c) When aqueous sodium hydroxide was added to the cooled reaction mixture, it initially reacted with excess sulfuric acid.

Write the ionic equation for this reaction.

[1]

(d) (i) Name the blue precipitate **X**.

.....[1]

(ii) Write an ionic equation, including state symbols, to show the formation of this blue precipitate.

[2]

(e) Calculate the empirical formula of the black solid **V**.

empirical formula of **V** is [2]

[Total: 8]

A3 Uranium is a radioactive metal. It has two main isotopes, uranium-235 with a nucleon number of 235 and uranium-238 with a nucleon number of 238.

(a) (i) State one similarity, in terms of sub-atomic particles, between uranium-235 and uranium-238.

.....
.....[1]

(ii) State one difference, in terms of sub-atomic particles, between uranium-235 and uranium-238.

.....
.....[1]

(b) Uranium is manufactured from uranium(IV) oxide, UO_2 , in a two-step process.

Step 1 – uranium(IV) oxide is heated with hydrogen fluoride to make uranium(IV) fluoride, UF_4 , and water.

Step 2 – uranium(IV) fluoride is reduced by magnesium to give uranium and one other product.

(i) Construct the equation for step 1.

[1]

(ii) Construct the equation for step 2.

[1]

(iii) Step 2 involves a reduction.
Explain the meaning of the term *reduction*?

.....
.....
.....[1]

- (iv) Calculate the mass of uranium that can be made from 1.00 tonne of uranium(IV) oxide.

[One tonne is one million grams.]

For
Examiner's
Use

mass of uranium = tonnes [3]

- (c) Uranium reacts with dilute hydrochloric acid to form hydrogen.
Using this information and your knowledge of the reactivity of metals, suggest where in the following reactivity series you would place uranium.

most reactive

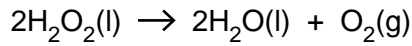
**potassium
sodium
calcium
magnesium
copper
silver**

least reactive

.....[1]

[Total: 9]

A4 Hydrogen peroxide, H₂O₂, is a covalent compound. Hydrogen peroxide decomposes to form water and oxygen.



(a) Draw a 'dot-and-cross' diagram for a molecule of hydrogen peroxide.

[2]

(b) The decomposition of hydrogen peroxide involves a change from the liquid state to the gaseous state. Describe the difference in both the movement and arrangement of particles in a liquid and in a gas.

.....
.....
.....
.....[2]

(c) At room temperature pure hydrogen peroxide decomposes much faster than dilute aqueous hydrogen peroxide. Explain why in terms of collision theory.

.....
.....
.....
.....[2]

(d) When aqueous iron(II) ions are warmed with aqueous hydrogen peroxide, iron(III) ions are formed.

(i) Construct an ionic equation for the oxidation of iron(II) ions to iron(III) ions.

[1]

- (ii) Describe a chemical test that can be used to confirm that iron(II) ions have been oxidised to form iron(III) ions.

For
Examiner's
Use

.....
.....
.....
.....[2]

- (e) Aqueous hydrogen peroxide was added to acidified aqueous potassium manganate(VII). The purple solution turned colourless.

Aqueous hydrogen peroxide was added to acidified aqueous potassium iodide. The colourless solution turned brown.

What deductions can you make about hydrogen peroxide from these two observations? Explain your answer.

.....
.....
.....
.....[2]

[Total: 11]

A5 Clean, dry air contains a mixture of gases including oxygen, nitrogen, carbon dioxide and the noble gases.

(a) Give the percentage by volume of nitrogen in clean, dry air.

.....[1]

(b) State and explain how oxygen is extracted from air.

.....
.....
.....
.....
.....
.....[3]

(c) Explain how the carbon cycle helps to keep the composition of air relatively constant.

.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....[4]

(d) Many electricity power stations burn fossil fuels. Sulfur dioxide is a pollutant produced during the burning of fossil fuels. Sulfur dioxide causes acid rain.

Describe **two** ways in which calcium carbonate can be used to reduce the effects of burning fossil fuels.

1

.....

2

.....[2]

[Total: 10]

Section B

Answer **three** questions from this section in the spaces provided.

The total mark for this section is 30.

For
Examiner's
Use

B6 Electrolysis involves the chemical decomposition of a compound, either when molten or in aqueous solution, by the passage of an electric current.

(a) Explain why aqueous calcium nitrate can be electrolysed but liquid pentane cannot.

.....
.....
.....
.....[2]

(b) State the products of the electrolysis of molten sodium chloride.

.....[1]

(c) State the products of the electrolysis of concentrated aqueous sodium chloride.

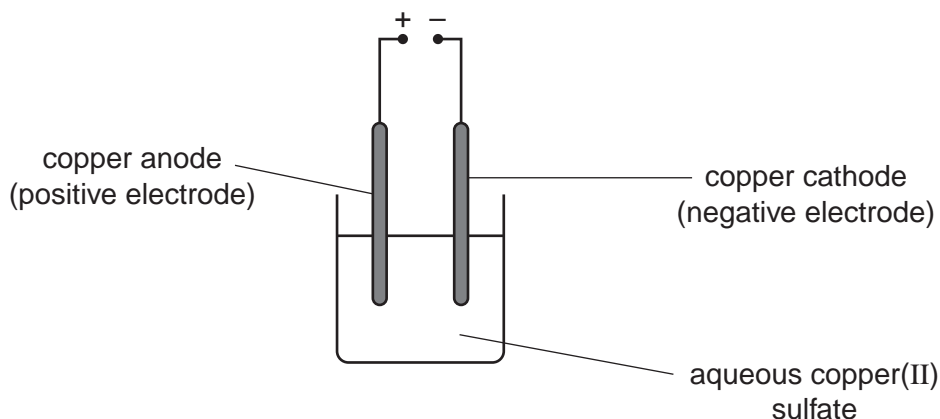
.....[1]

(d) Describe the essential details of the manufacture of aluminium by electrolysis.

.....
.....
.....
.....[2]

- (e) A student investigates the electrolysis of aqueous copper(II) sulfate using the apparatus shown below.

For
Examiner's
Use



The student weighs the copper cathode before and after the electrolysis.

experiment number	current used / A	time taken / s	mass of cathode	
			before starting / g	after electrolysis / g
1	2.0	180	1.24	1.36
2	4.0	180	1.20	1.44
3	2.0	360	1.34	1.58

- (i) Explain, with the aid of an equation, why the cathode increases in mass.

.....

[2]

- (ii) In experiment 2 the student measures the mass of the anode both before and after the electrolysis.

At the start the anode has a mass of 1.45 g.

Determine the mass of the anode at the end of the electrolysis.

mass of anode at end = g [1]

- (iii) The student does a fourth experiment, this time using a current of 8.0A for 90 seconds. At the start the cathode has a mass of 1.51 g. Predict the mass of the cathode at the end of the electrolysis.

For
Examiner's
Use

mass of cathode at end = g [1]

[Total: 10]

- B7** Alcohols are a homologous series of organic compounds.
The table shows some information about the first five alcohols.

For
Examiner's
Use

name	molecular formula
methanol	CH_4O
ethanol	$\text{C}_2\text{H}_6\text{O}$
	$\text{C}_3\text{H}_8\text{O}$
butanol	$\text{C}_4\text{H}_{10}\text{O}$
pentanol	$\text{C}_5\text{H}_{12}\text{O}$

- (a) Suggest the name of the alcohol with the molecular formula $\text{C}_3\text{H}_8\text{O}$.

.....[1]

- (b) Draw the structure of an alcohol with the molecular formula $\text{C}_4\text{H}_{10}\text{O}$ and explain why this alcohol is saturated.

.....
.....[2]

- (c) Deduce the molecular formula of an alcohol that contains seven carbon atoms.

.....[1]

- (d) Ethanol reacts with ethanoic acid to form ethyl ethanoate.

- (i) Draw the structure of ethyl ethanoate.

[1]

- (ii) Suggest a use for ethyl ethanoate.

.....[1]

(e) Describe, with the aid of an equation, how ethanol is manufactured by fermentation.

.....
.....
.....
.....
.....[3]

(f) When ethanol is heated with concentrated sulfuric acid a colourless gas, **A**, is produced. Gas **A** will decolourise aqueous bromine.

Identify gas **A**.

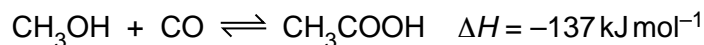
.....[1]

[Total: 10]

For
Examiner's
Use

B8 Ethanoic acid is manufactured by a reaction between methanol, CH_3OH , and carbon monoxide.

For
Examiner's
Use



This reaction is exothermic.

(a) The reaction is carried out at a pressure of 30 atmospheres and a temperature of 180°C .

(i) Predict and explain the effect on the position of equilibrium if the reaction is carried out at 30 atmospheres pressure and 20°C rather than 180°C .

.....

[2]

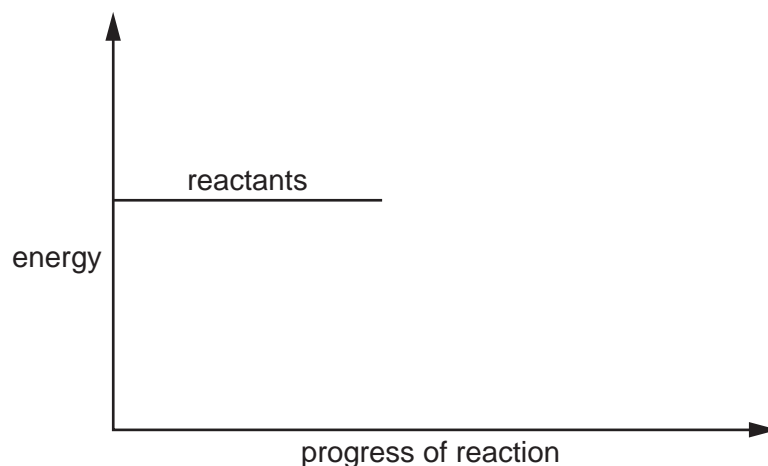
(ii) Suggest one reason why the reaction is carried out at 180°C rather than 20°C .

.....
[1]

(b) Complete the energy profile diagram for the reaction between methanol and carbon monoxide.

On your diagram label the

- product,
- activation energy, E_a ,
- enthalpy change for the reaction, ΔH .



[3]

- (c) The manufacture of ethanoic acid from methanol also uses a catalyst to increase the speed of reaction.

Explain how a catalyst increases the speed of reaction.

.....
.....[1]

- (d) In an investigation 10.0 moles of methanol are mixed with 20.0 moles of carbon monoxide.

At the end of the reaction 9.8 moles of ethanoic acid are formed.

Calculate the percentage yield of ethanoic acid.

percentage yield = % [2]

- (e) Ethanoic acid reacts with ammonia to form a salt.

Give the formula of this salt.

.....[1]

[Total: 10]

B9 Sulfamic acid, SO_3NH_2 , is a weak acid used to remove limescale from kettles.

For
Examiner's
Use

(a) Explain the meaning of the term *weak acid*?

.....
.....[1]

(b) The pH of an aqueous solution of sulfamic acid can be determined using a pH meter. Describe another way of estimating the pH of a solution of sulfamic acid.

.....
.....
.....[2]

(c) A 0.105 g sample of sulfamic acid is dissolved in 25.0cm^3 of water. The sulfamic acid solution requires 10.8cm^3 of 0.100mol dm^{-3} potassium hydroxide for complete neutralisation.

Calculate the number of moles of sulfamic acid that react with one mole of potassium hydroxide.

number of moles of sulfamic acid = [3]

(d) Aqueous sulfamic acid reacts with magnesium to form magnesium sulfamate, $\text{Mg}(\text{SO}_3\text{NH}_2)_2$.

(i) Write an equation for this reaction.

[1]

(ii) Limescale contains calcium carbonate. Describe, with the aid of an equation, how aqueous sulfamic acid reacts with calcium carbonate.

.....[2]

(e) Sulfamic acid reacts with sodium nitrite, NaNO_2 , to form water, sodium hydrogensulfate, NaHSO_4 , and a colourless gas. Suggest the identity of the colourless gas.

.....[1]

[Total: 10]

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DATA SHEET
The Periodic Table of the Elements

		Group																																																																																																																																																																																																																					
I	II	III	IV	V	VI	VII	0					0																																																																																																																																																																																																											
7 Li Lithium 3	9 Be Beryllium 4	1 H Hydrogen 1	11 B Boron 5	12 C Carbon 6	13 Al Aluminium 13	14 Si Silicon 14	15 P Phosphorus 15	16 S Sulfur 16	17 Cl Chlorine 17	18 Ar Argon 18	19 F Fluorine 9	20 Ne Neon 10																																																																																																																																																																																																											
23 Na Sodium 11	24 Mg Magnesium 12	27 Co Cobalt 27	28 Ni Nickel 28	29 Cu Copper 29	30 Zn Zinc 30	31 Ga Gallium 31	32 Ge Germanium 32	33 As Arsenic 33	34 Se Selenium 34	35 Br Bromine 35	36 Kr Krypton 36	37 Rb Rubidium 37	38 Sr Strontium 38	39 Y Yttrium 39	40 Ca Calcium 20	41 Ti Titanium 22	42 V Vanadium 23	43 Cr Chromium 24	44 Mn Manganese 25	45 Fe Iron 26	46 Ru Ruthenium 44	47 Rh Rhodium 45	48 Pd Palladium 46	49 Ag Silver 47	50 Cd Cadmium 48	51 In Indium 49	52 Sn Tin 50	53 Sb Antimony 51	54 Te Tellurium 52	55 Cs Caesium 55	56 Ba Barium 56	57 La Lanthanum 57	58 Ce Cerium 58	59 Pr Praseodymium 59	60 Nd Neodymium 60	61 Pm Promethium 61	62 Sm Samarium 62	63 Eu Europium 63	64 Gd Gadolinium 64	65 Tb Terbium 65	66 Dy Dysprosium 66	67 Ho Holmium 67	68 Er Erbium 68	69 Tm Thulium 69	70 Yb Ytterbium 70	71 Lu Lutetium 71																																																																																																																																																																									
85 Rb Rubidium 37	86 Sr Strontium 38	87 Fr Francium 87	88 Sr Strontium 38	89 Y Yttrium 39	90 Zr Zirconium 40	91 Nb Niobium 41	92 Hf Hafnium 72	93 Ta Tantalum 73	94 Pu Plutonium 94	95 Am Americium 95	96 Cm Curium 96	97 Bk Berkelium 97	98 Cf Californium 98	99 Es Einsteinium 99	100 Fm Fermium 100	101 Md Mendelevium 101	102 No Nobelium 102	103 Lr Lawrencium 103	104 Rf Rutherfordium 104	105 Db Dubnium 105	106 Sg Seaborgium 106	107 Bh Bohrium 107	108 Hs Hassium 108	109 Mt Meitnerium 109	110 Ds Darmstadtium 110	111 Rg Roentgenium 111	112 Cn Copernicium 112	113 Nh Nihonium 113	114 Fl Flerovium 114	115 Mc Moscovium 115	116 Lv Livermorium 116	117 Ts Tennessine 117	118 Og Oganesson 118	119 Uu Ununennium 119	120 Uub Unbibium 120	121 Uut Untrium 121	122 Uuq Unquadrium 122	123 Uuq Unquadrium 123	124 Uup Unpentium 124	125 Uuq Unquadrium 125	126 Uuh Unhexium 126	127 Uuq Unquadrium 127	128 Uuq Unquadrium 128	129 Uuq Unquadrium 129	130 Uuq Unquadrium 130	131 Uuq Unquadrium 131	132 Uuq Unquadrium 132	133 Uuq Unquadrium 133	134 Uuq Unquadrium 134	135 Uuq Unquadrium 135	136 Uuq Unquadrium 136	137 Uuq Unquadrium 137	138 Uuq Unquadrium 138	139 Uuq Unquadrium 139	140 Uuq Unquadrium 140	141 Uuq Unquadrium 141	142 Uuq Unquadrium 142	143 Uuq Unquadrium 143	144 Uuq Unquadrium 144	145 Uuq Unquadrium 145	146 Uuq Unquadrium 146	147 Uuq Unquadrium 147	148 Uuq Unquadrium 148	149 Uuq Unquadrium 149	150 Uuq Unquadrium 150	151 Uuq Unquadrium 151	152 Uuq Unquadrium 152	153 Uuq Unquadrium 153	154 Uuq Unquadrium 154	155 Uuq Unquadrium 155	156 Uuq Unquadrium 156	157 Uuq Unquadrium 157	158 Uuq Unquadrium 158	159 Uuq Unquadrium 159	160 Uuq Unquadrium 160	161 Uuq Unquadrium 161	162 Uuq Unquadrium 162	163 Uuq Unquadrium 163	164 Uuq Unquadrium 164	165 Uuq Unquadrium 165	166 Uuq Unquadrium 166	167 Uuq Unquadrium 167	168 Uuq Unquadrium 168	169 Uuq Unquadrium 169	170 Uuq Unquadrium 170	171 Uuq Unquadrium 171	172 Uuq Unquadrium 172	173 Uuq Unquadrium 173	174 Uuq Unquadrium 174	175 Uuq Unquadrium 175	176 Uuq Unquadrium 176	177 Uuq Unquadrium 177	178 Uuq Unquadrium 178	179 Uuq Unquadrium 179	180 Uuq Unquadrium 180	181 Uuq Unquadrium 181	182 Uuq Unquadrium 182	183 Uuq Unquadrium 183	184 Uuq Unquadrium 184	185 Uuq Unquadrium 185	186 Uuq Unquadrium 186	187 Uuq Unquadrium 187	188 Uuq Unquadrium 188	189 Uuq Unquadrium 189	190 Uuq Unquadrium 190	191 Uuq Unquadrium 191	192 Uuq Unquadrium 192	193 Uuq Unquadrium 193	194 Uuq Unquadrium 194	195 Uuq Unquadrium 195	196 Uuq Unquadrium 196	197 Uuq Unquadrium 197	198 Uuq Unquadrium 198	199 Uuq Unquadrium 199	200 Uuq Unquadrium 200	201 Uuq Unquadrium 201	202 Uuq Unquadrium 202	203 Uuq Unquadrium 203	204 Uuq Unquadrium 204	205 Uuq Unquadrium 205	206 Uuq Unquadrium 206	207 Uuq Unquadrium 207	208 Uuq Unquadrium 208	209 Uuq Unquadrium 209	210 Uuq Unquadrium 210	211 Uuq Unquadrium 211	212 Uuq Unquadrium 212	213 Uuq Unquadrium 213	214 Uuq Unquadrium 214	215 Uuq Unquadrium 215	216 Uuq Unquadrium 216	217 Uuq Unquadrium 217	218 Uuq Unquadrium 218	219 Uuq Unquadrium 219	220 Uuq Unquadrium 220	221 Uuq Unquadrium 221	222 Uuq Unquadrium 222	223 Uuq Unquadrium 223	224 Uuq Unquadrium 224	225 Uuq Unquadrium 225	226 Uuq Unquadrium 226	227 Uuq Unquadrium 227	228 Uuq Unquadrium 228	229 Uuq Unquadrium 229	230 Uuq Unquadrium 230	231 Uuq Unquadrium 231	232 Uuq Unquadrium 232	233 Uuq Unquadrium 233	234 Uuq Unquadrium 234	235 Uuq Unquadrium 235	236 Uuq Unquadrium 236	237 Uuq Unquadrium 237	238 Uuq Unquadrium 238	239 Uuq Unquadrium 239	240 Uuq Unquadrium 240	241 Uuq Unquadrium 241	242 Uuq Unquadrium 242	243 Uuq Unquadrium 243	244 Uuq Unquadrium 244	245 Uuq Unquadrium 245	246 Uuq Unquadrium 246	247 Uuq Unquadrium 247	248 Uuq Unquadrium 248	249 Uuq Unquadrium 249	250 Uuq Unquadrium 250	251 Uuq Unquadrium 251	252 Uuq Unquadrium 252	253 Uuq Unquadrium 253	254 Uuq Unquadrium 254	255 Uuq Unquadrium 255	256 Uuq Unquadrium 256	257 Uuq Unquadrium 257	258 Uuq Unquadrium 258	259 Uuq Unquadrium 259	260 Uuq Unquadrium 260	261 Uuq Unquadrium 261	262 Uuq Unquadrium 262	263 Uuq Unquadrium 263	264 Uuq Unquadrium 264	265 Uuq Unquadrium 265	266 Uuq Unquadrium 266	267 Uuq Unquadrium 267	268 Uuq Unquadrium 268	269 Uuq Unquadrium 269	270 Uuq Unquadrium 270	271 Uuq Unquadrium 271	272 Uuq Unquadrium 272	273 Uuq Unquadrium 273	274 Uuq Unquadrium 274	275 Uuq Unquadrium 275	276 Uuq Unquadrium 276	277 Uuq Unquadrium 277	278 Uuq Unquadrium 278	279 Uuq Unquadrium 279	280 Uuq Unquadrium 280	281 Uuq Unquadrium 281	282 Uuq Unquadrium 282	283 Uuq Unquadrium 283	284 Uuq Unquadrium 284	285 Uuq Unquadrium 285	286 Uuq Unquadrium 286	287 Uuq Unquadrium 287	288 Uuq Unquadrium 288	289 Uuq Unquadrium 289	290 Uuq Unquadrium 290	291 Uuq Unquadrium 291	292 Uuq Unquadrium 292	293 Uuq Unquadrium 293	294 Uuq Unquadrium 294	295 Uuq Unquadrium 295	296 Uuq Unquadrium 296	297 Uuq Unquadrium 297	298 Uuq Unquadrium 298	299 Uuq Unquadrium 299	300 Uuq Unquadrium 300

* 58–71 Lanthanoid series
† 90–103 Actinoid series

Key

a	X
b	

 a = relative atomic mass
 X = atomic symbol
 b = atomic (proton) number

The volume of one mole of any gas is 24 dm³ at room temperature and pressure (r.t.p.).