



basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

NATIONAL SENIOR CERTIFICATE

GRADE 11

PHYSICAL SCIENCES: CHEMISTRY (P2)

NOVEMBER 2018

MARKS: 150

TIME: 3 hours

This question paper consists of 12 pages, 4 data sheets and 1 answer sheet.



INSTRUCTIONS AND INFORMATION

1. Write your name and class (e.g. 11A) in the appropriate spaces on the ANSWER BOOK.
2. This question paper contains 10 questions.
3. Hand in the ANSWER SHEET with the ANSWER BOOK.
4. Start EACH question on a NEW page in the ANSWER BOOK.
5. Number the answers correctly according to the numbering system used in this question paper.
6. Leave ONE line between two subquestions, e.g. between QUESTION 2.1 and QUESTION 2.2.
7. You may use a non-programmable calculator.
8. You may use appropriate mathematical instruments.
9. You are advised to use the attached DATA SHEETS.
10. Show ALL formulae and substitutions in ALL calculations.
11. Round off your FINAL numerical answers to a minimum of TWO decimal places.
12. Give brief motivations, discussions, etc. where required.
13. Write neatly and legibly.



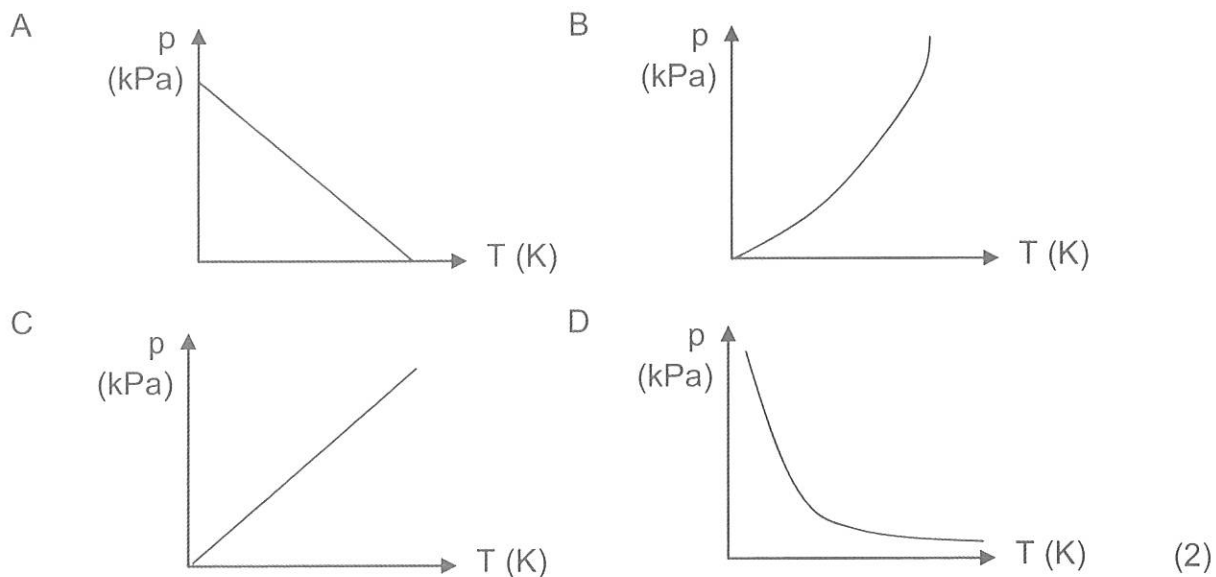
QUESTION 1: MULTIPLE-CHOICE QUESTIONS

Various options are provided as possible answers to the following questions. Choose the answer and write only the letter (A–D) next to the question numbers (1.1 to 1.10) in the ANSWER BOOK, e.g. 1.11 E.

- 1.1 The tendency of an atom to attract the bonding pair of electrons is known as ...
A electron affinity.
B electronegativity.
C polarity.
D activation energy. (2)
- 1.2 Bond length is the average distance between the ...
A orbitals of two bonded atoms.
B electrons in two bonded atoms.
C nuclei of two bonded atoms.
D molecules of the same substance. (2)
- 1.3 Hydrogen bonds and London forces (induced dipole forces) have a common characteristic in that they ...
A are both stronger than chemical bonds.
B both occur between non-polar molecules.
C both occur between polar molecules.
D are both intermolecular forces. (2)
- 1.4 In order to double the volume of a fixed amount of moles of an enclosed gas, the temperature in ... at constant pressure.
A °C can be doubled
B K can be doubled
C °C can be halved
D K can be halved (2)



- 1.5 The graph that CORRECTLY represents the relationship between the pressure (kPa) and the temperature (K) of an enclosed gas at constant volume is ...



- 1.6 The solution that will have the greatest concentration of H^+ ions if complete ionisation takes place, is ...

- A 0,4 dm³ of a 1 mol·dm⁻³ H_2SO_4 solution.
B 0,4 dm³ of a 1 mol·dm⁻³ HCl solution.
C 1 dm³ of a 1 mol·dm⁻³ HCl solution.
D 0,4 dm³ of a 1 mol·dm⁻³ CH_3COOH solution. (2)

- 1.7 Which ONE of the following is NOT a typical reaction of hydrochloric acid?

- A It neutralises a base with the release of hydrogen gas.
B It forms hydronium ions in water.
C It colours litmus paper red.
D It forms CO_2 when reacting with a metal carbonate. (2)

- 1.8 Which ONE of the following pairs represents the conjugate acid and conjugate base of HPO_4^{2-} ?

	CONJUGATE ACID	CONJUGATE BASE
A	PO_4^{3-}	H_2PO_4^-
B	H_2PO_4^-	PO_4^{3-}
C	H_2PO_4^-	H_3PO_4
D	$\text{H}_2\text{PO}_4^{2-}$	PO_4^{2-}

(2)

- 1.9 Which ONE of the following indicates the CORRECT colour of bromothymol blue in an acid and a base?

	BROMOTHYMOL BLUE IN AN ACID	BROMOTHYMOL BLUE IN A BASE
A	Orange	Yellow
B	Blue	Red
C	Pink	Colourless
D	Yellow	Blue

(2)

- 1.10 In which ONE of the following reactions is HCl oxidised?

- A $\text{HCl}(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightarrow \text{H}_3\text{O}^+(\text{aq}) + \text{Cl}^-(\text{aq})$
- B $\text{CaCO}_3(\text{s}) + 2\text{HCl}(\text{aq}) \rightarrow \text{CaCl}_2(\text{aq}) + \text{H}_2\text{O}(\text{l}) + \text{CO}_2(\text{g})$
- C $\text{NH}_3(\text{aq}) + \text{HCl}(\text{aq}) \rightarrow \text{NH}_4\text{Cl}(\text{aq})$
- D $\text{MnO}_2(\text{aq}) + 4\text{HCl}(\text{aq}) \rightarrow \text{MnCl}_2(\text{aq}) + \text{H}_2\text{O}(\text{l}) + \text{Cl}_2(\text{g})$

(2)
[20]

QUESTION 2 (Start on a new page.)

Hydrogen cyanide (HCN) is a very poisonous compound used in the manufacturing of plastics, mining of gold and as a poison.

- 2.1 Define the term *chemical bond*. (2)
- 2.2 Draw Lewis structures for:
- 2.2.1 HCN (2)
- 2.2.2 H₂O (2)
- 2.3 What is the shape of the HCN molecule? (1)
- 2.4 Calculate the electronegativity difference for the CN bond. (1)
- 2.5 What is polarity of the HCN molecule? Write only POLAR or NON-POLAR. (1)

The table below indicates the values of the bond length and bond energy of the different bonds in HCN.

BOND	BOND LENGTH (nm)	BOND ENERGY (kJ·mol ⁻¹)
CH	0,109	413
CN	0,116	890

- 2.6 Explain why the bond energy of the CN bond is more than the bond energy of the CH bond. (2)
- 2.7 Explain the difference between the *bond length of the CH bond* and the *bond length of the CN bond*. (2)
- 2.8 Will HCN be soluble in water? Write only YES or NO. (1)
- 2.9 Explain the answer to QUESTION 2.8 by referring to the polarity and intermolecular forces of the compounds. (3)

[17]

QUESTION 3 (Start on a new page.)

The reaction below is used in the Haber process to manufacture ammonia.



The boiling points of the substances in the reaction are as follows:

SUBSTANCE	BOILING POINT (°C)
H ₂	-252,9
N ₂	-195,8
NH ₃	-33,3

- 3.1 Refer to the intermolecular forces and explain the difference in boiling point between NH₃ and N₂. (3)
- 3.2 Write down the FORMULA of the substance in the table that will have the lowest melting point. (1)
- 3.3 Explain why H₂ will evaporate faster than N₂. Refer to the type and relative strength of the intermolecular forces. (3)
- 3.4 Write down the FORMULA of the substance in the table that will have the highest vapour pressure. Explain your answer. (3)
- [10]**



QUESTION 4 (Start on a new page.)

A certain amount of gas is sealed in a container of which the volume can change. The relationship between the pressure and volume of the gas at 20 °C is investigated. The results of the experiment are given in the table below.

PRESSURE (kPa)	VOLUME (dm ³)
70	174
95	128
130	93,6
165	74
205	59
240	51
260	47

- 4.1 Name the gas law that is represented by the results of the experiment. (1)
- 4.2 Write down a hypothesis for the investigation. (2)
- 4.3 Draw a graph of volume versus pressure on the ANSWER SHEET attached. (3)
- 4.4 Calculate the volume of the gas at 300 kPa. (3)
- 4.5 When the volume of the gas is measured at 300 kPa, it is 44 dm³. Explain why the measured volume differs from the volume calculated in QUESTION 4.4. (2)
- 4.6 Which temperature condition will cause a gas to deviate from ideal behaviour? Write only HIGH or LOW. (1)
- 4.7 Explain the answer to QUESTION 4.6. (2)
- 4.8 Calculate the number of moles of the gas in the container at the INITIAL pressure and volume. (4)
- [18]**

QUESTION 5 (Start on a new page.)

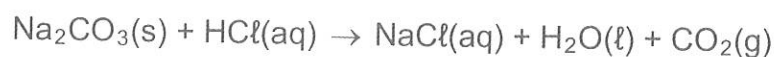
A balloon is filled with 160 g of argon gas (Ar). The pressure of the gas is 120 kPa at a temperature of 15 °C.

- 5.1 Calculate the volume of the balloon. (4)
- 5.2 The temperature of the gas is now increased BY 20 °C and the initial pressure is doubled. Calculate the new volume of the balloon. (4)
- [8]**

QUESTION 6 (Start on a new page.)

- 6.1 In an experiment, a learner added 1,5 g of sodium carbonate (Na_2CO_3) to hydrochloric acid (HCl). A volume of 306 cm^3 of carbon dioxide gas was formed and collected under standard pressure at room temperature. Take the molar gas volume at room temperature (V_m) as 24,45 dm^3 .

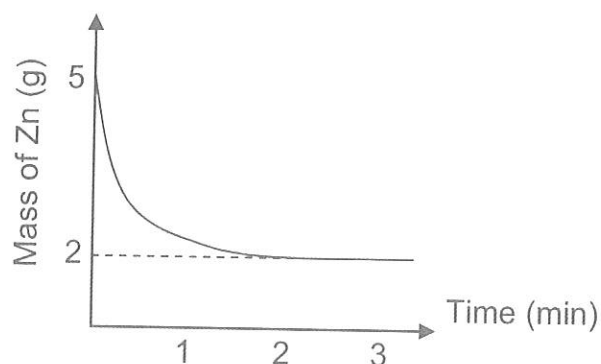
The unbalanced equation for the reaction is:



- 6.1.1 Define the term *one mole of a substance*. (2)
- 6.1.2 Balance the equation for the reaction. (2)
- 6.1.3 Calculate the mass of sodium carbonate that reacted. (7)
- 6.1.4 Calculate the percentage of sodium carbonate in excess. (2)
- 6.2 Zinc reacts with sulphuric acid according to the reaction below.



The mass of zinc is recorded during the experiment and is shown on the graph below. The reaction stops after 2 minutes.

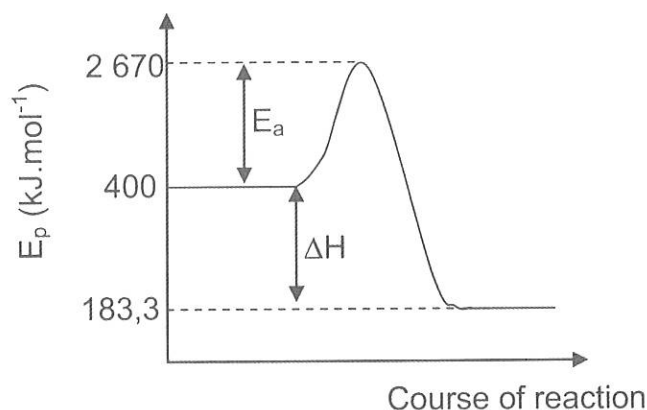


- 6.2.1 Name the substance that is the limiting reagent. (1)
- 6.2.2 Calculate the initial concentration of the sulphuric acid if 50 cm^3 of the acid was used. (5)
- [19]**



QUESTION 7 (Start on a new page.)

The following reaction between ammonia and oxygen takes place in a closed system at constant pressure and temperature:



- 7.1 Define the term *activation energy*. (2)
- 7.2 Give a reason why this reaction is exothermic. (1)
- 7.3 Calculate the heat of reaction. (3)
- 7.4 Redraw the graph and indicate with a dotted line the effect of a catalyst on the activation energy. (2)
- 7.5 State *Avogadro's law* in words. (2)
- 7.6 If 6 dm³ of NH₃ and 9 dm³ of O₂ are used, calculate the TOTAL VOLUME of the gases at the end of the reaction. (4)
- 7.7 The reaction above is the first step in the manufacturing of an acid. This acid contains 1,59% hydrogen, 22,2% nitrogen and 76,2% oxygen. Determine the empirical formula of the acid. (5)
- [19]**

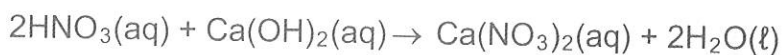
QUESTION 8 (Start on a new page.)

Ammonia can readily dissolve in water according to the equation below:



- 8.1 Explain why a hydroxide ion is regarded as a Lowry-Brønsted base. (2)
- 8.2 Identify the type of bond responsible for the formation of the ammonium ion in the above equation. (1)
- 8.3 Write a balanced equation to show how the ampholyte in the above equation will act as a base when it reacts with hydrochloric acid (HCl). (2)

5 dm³ of nitric acid (HNO₃), with a concentration of 0,75 mol·dm⁻³, is spilled accidentally in a small pond of water. The acid and water has a total volume of 1 000 dm³. To neutralise the acid, calcium hydroxide is added to the water.

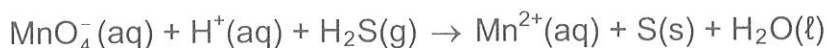


- 8.4 Define the term *concentration*. (2)
- 8.5 Calculate the concentration of the acid AFTER it was spilled in the pond. (4)
- 8.6 Use calculations to determine if 120 g of calcium hydroxide will be sufficient to react completely with ALL the acid in the pond. (6)
- [17]



QUESTION 9 (Start on a new page.)

The reaction between permanganate ions (MnO_4^-) and hydrogen sulphide (H_2S) is given below.

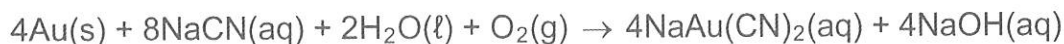


- 9.1 Define *reduction* in terms of oxidation numbers. (2)
- 9.2 Determine the oxidation number of manganese in the permanganate ion. (1)
- 9.3 Write down the FORMULA of the substance that undergoes oxidation. (1)
- 9.4 Explain the answer to QUESTION 9.3 in terms of oxidation numbers. (2)
- 9.5 Write down the FORMULA for the oxidising agent. (1)
- 9.6 Write down the oxidation half-reaction. (2)
- 9.7 Use the ion-electron method and write down the balanced net ionic equation. (3)
- [12]**

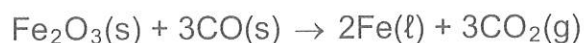
QUESTION 10 (Start on a new page.)

Gold and iron extraction are important mining processes in South Africa. Refining takes place according to the following reactions:

Gold is dissolved using cyanide ions (CN^-) to extract it from the ore:



Iron(III)oxide is burned in a furnace in the presence of CO:



- 10.1 Name TWO disadvantages of deep-shaft mining in comparison with open-cast mining. (2)
- 10.2 Write down the FORMULA of the substance that is reduced in the reaction used to extract gold. (1)
- 10.3 Use oxidation numbers to explain how you arrived at the answer to QUESTION 10.2. (1)
- 10.4 Write the reduction half-reaction for the iron extraction reaction. (2)
- 10.5 Calculate the percentage of iron present in Fe_2O_3 . (2)
- 10.6 Only 65% of the ore contains iron. If 2 500 kg of ore is used, calculate the mass of iron that can be extracted from the ore. (2)
- [10]**

TOTAL: 150



**DATA FOR PHYSICAL SCIENCES GRADE 11
PAPER 2 (CHEMISTRY)**

**GEGEWENS VIR FISIESTE WETENSKAPPE GRAAD 11
VRAESTEL 2 (CHEMIE)**

TABLE 1: PHYSICAL CONSTANTS/TABEL 1: FISIESTE KONSTANTES

NAME/NAAM	SYMBOL/SIMBOOL	VALUE/WAARDE
Avogadro's constant <i>Avogadro-konstante</i>	N_A	$6,02 \times 10^{23} \text{ mol}^{-1}$
Molar gas constant <i>Molêre gaskonstante</i>	R	$8,31 \text{ J} \cdot \text{K}^{-1} \cdot \text{mol}^{-1}$
Standard pressure <i>Standaarddruk</i>	p^θ	$1,013 \times 10^5 \text{ Pa}$
Molar gas volume at STP <i>Molêre gasvolume by STD</i>	V_m	$22,4 \text{ dm}^3 \cdot \text{mol}^{-1}$
Standard temperature <i>Standaardtemperatuur</i>	T^θ	273 K

TABLE 2: FORMULAE/TABEL 2: FORMULES

$\frac{p_1 V_1}{T_1} = \frac{p_2 V_2}{T_2}$	$pV = nRT$
$n = \frac{m}{M}$	$n = \frac{N}{N_A}$
$n = \frac{V}{V_m}$	$c = \frac{n}{V}$ OR/OF $c = \frac{m}{MV}$



TABLE 3: THE PERIODIC TABLE OF ELEMENTS/TABEL 3: DIE PERIODIEKE TABEL VAN ELEMENTE

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18																																																																																																																																																																																																																																																																																																																																																																																																																																										
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1 2,0 H	3 7 1,0 Li	11 23 0,9 Na	19 39 0,8 K	21 45 1,0 Sc	23 51 1,0 V	24 52 1,0 Cr	25 55 1,0 Mn	26 56 1,0 Fe	27 59 1,0 Co	28 59 1,0 Ni	29 63,5 1,0 Cu	30 65 1,0 Zn	31 70 1,6 Ga	32 73 1,8 Ge	33 75 2,0 As	34 79 2,4 Se	35 80 2,8 Br	36 84 2,4 Kr																																																																																																																																																																																																																																																																																																																																																																																																																																									
2 4 10 He	4 9 1,0 Be	12 24 1,2 Mg	20 40 1,0 Ca	39 88 1,0 Sr	56 137 0,6 Ba	86 133 0,7 Cs	87 226 0,7 Fr	88 226 0,6 Ra	89 226 0,6 Ac	90 232 0,6 Th	91 238 0,6 Pa	92 238 0,6 U	93 238 0,6 Np	94 238 0,6 Pu	95 238 0,6 Am	96 238 0,6 Cm	97 238 0,6 Bk	98 238 0,6 Cf	99 238 0,6 Es	100 238 0,6 Fm	101 238 0,6 Md	102 238 0,6 No	103 238 0,6 Lr																																																																																																																																																																																																																																																																																																																																																																																																																																				
3 7 1,0 Li	4 9 1,0 Be	11 23 0,9 Na	19 39 0,8 K	21 45 1,0 Sc	23 51 1,0 V	24 52 1,0 Cr	25 55 1,0 Mn	26 56 1,0 Fe	27 59 1,0 Co	28 59 1,0 Ni	29 63,5 1,0 Cu	30 65 1,0 Zn	31 70 1,6 Ga	32 73 1,8 Ge	33 75 2,0 As	34 79 2,4 Se	35 80 2,8 Br	36 84 2,4 Kr	37 86 2,4 Rb	38 88 1,0 Sr	39 89 1,0 Y	40 90 1,0 Zr	41 91 1,0 Nb	42 92 1,0 Mo	43 93 1,0 Tc	44 94 1,0 Ru	45 95 1,0 Rh	46 96 1,0 Pd	47 97 1,0 Ag	48 98 1,0 Cd	49 99 1,0 In	50 100 1,0 Sn	51 101 1,0 Sb	52 102 1,0 Te	53 103 1,0 I	54 104 1,0 Xe	55 105 1,0 Ba	56 106 1,0 La	57 107 1,0 Ce	58 108 1,0 Pr	59 109 1,0 Nd	60 110 1,0 Pm	61 111 1,0 Sm	62 112 1,0 Eu	63 113 1,0 Gd	64 114 1,0 Tb	65 115 1,0 Dy	66 116 1,0 Ho	67 117 1,0 Yb	68 118 1,0 Lu	69 119 1,0 Hf	70 120 1,0 Ta	71 121 1,0 W	72 122 1,0 Re	73 123 1,0 Os	74 124 1,0 Pt	75 125 1,0 Au	76 126 1,0 Hg	77 127 1,0 Tl	78 128 1,0 Pb	79 129 1,0 Bi	80 130 1,0 Po	81 131 1,0 At	82 132 1,0 Rn	83 133 1,0 Fr	84 134 1,0 Ra	85 135 1,0 Ac	86 136 1,0 Th	87 137 1,0 Pa	88 138 1,0 U	89 139 1,0 Np	90 140 1,0 Pu	91 141 1,0 Am	92 142 1,0 Cm	93 143 1,0 Bk	94 144 1,0 Cf	95 145 1,0 Es	96 146 1,0 Fm	97 147 1,0 Md	98 148 1,0 No	99 149 1,0 Lr	100 150 1,0 Lu	101 151 1,0 Hf	102 152 1,0 Ta	103 153 1,0 W	104 154 1,0 Re	105 155 1,0 Os	106 156 1,0 Pt	107 157 1,0 Au	108 158 1,0 Hg	109 159 1,0 Tl	110 160 1,0 Pb	111 161 1,0 Bi	112 162 1,0 Po	113 163 1,0 At	114 164 1,0 Rn	115 165 1,0 Fr	116 166 1,0 Ra	117 167 1,0 Ac	118 168 1,0 Th	119 169 1,0 Pa	120 170 1,0 U	121 171 1,0 Np	122 172 1,0 Pu	123 173 1,0 Am	124 174 1,0 Cm	125 175 1,0 Bk	126 176 1,0 Cf	127 177 1,0 Es	128 178 1,0 Fm	129 179 1,0 Md	130 180 1,0 No	131 181 1,0 Lr	132 182 1,0 Lu	133 183 1,0 Hf	134 184 1,0 Ta	135 185 1,0 W	136 186 1,0 Re	137 187 1,0 Os	138 188 1,0 Pt	139 189 1,0 Au	140 190 1,0 Hg	141 191 1,0 Tl	142 192 1,0 Pb	143 193 1,0 Bi	144 194 1,0 Po	145 195 1,0 At	146 196 1,0 Rn	147 197 1,0 Fr	148 198 1,0 Ra	149 199 1,0 Ac	150 200 1,0 Th	151 201 1,0 Pa	152 202 1,0 U	153 203 1,0 Np	154 204 1,0 Pu	155 205 1,0 Am	156 206 1,0 Cm	157 207 1,0 Bk	158 208 1,0 Cf	159 209 1,0 Es	160 210 1,0 Fm	161 211 1,0 Md	162 212 1,0 No	163 213 1,0 Lr	164 214 1,0 Lu	165 215 1,0 Hf	166 216 1,0 Ta	167 217 1,0 W	168 218 1,0 Re	169 219 1,0 Os	170 220 1,0 Pt	171 221 1,0 Au	172 222 1,0 Hg	173 223 1,0 Tl	174 224 1,0 Pb	175 225 1,0 Bi	176 226 1,0 Po	177 227 1,0 At	178 228 1,0 Rn	179 229 1,0 Fr	180 230 1,0 Ra	181 231 1,0 Ac	182 232 1,0 Th	183 233 1,0 Pa	184 234 1,0 U	185 235 1,0 Np	186 236 1,0 Pu	187 237 1,0 Am	188 238 1,0 Cm	189 239 1,0 Bk	190 240 1,0 Cf	191 241 1,0 Es	192 242 1,0 Fm	193 243 1,0 Md	194 244 1,0 No	195 245 1,0 Lr	196 246 1,0 Lu	197 247 1,0 Hf	198 248 1,0 Ta	199 249 1,0 W	200 250 1,0 Re	201 251 1,0 Os	202 252 1,0 Pt	203 253 1,0 Au	204 254 1,0 Hg	205 255 1,0 Tl	206 256 1,0 Pb	207 257 1,0 Bi	208 258 1,0 Po	209 259 1,0 At	210 260 1,0 Rn	211 261 1,0 Fr	212 262 1,0 Ra	213 263 1,0 Ac	214 264 1,0 Th	215 265 1,0 Pa	216 266 1,0 U	217 267 1,0 Np	218 268 1,0 Pu	219 269 1,0 Am	220 270 1,0 Cm	221 271 1,0 Bk	222 272 1,0 Cf	223 273 1,0 Es	224 274 1,0 Fm	225 275 1,0 Md	226 276 1,0 No	227 277 1,0 Lr	228 278 1,0 Lu	229 279 1,0 Hf	230 280 1,0 Ta	231 281 1,0 W	232 282 1,0 Re	233 283 1,0 Os	234 284 1,0 Pt	235 285 1,0 Au	236 286 1,0 Hg	237 287 1,0 Tl	238 288 1,0 Pb	239 289 1,0 Bi	240 290 1,0 Po	241 291 1,0 At	242 292 1,0 Rn	243 293 1,0 Fr	244 294 1,0 Ra	245 295 1,0 Ac	246 296 1,0 Th	247 297 1,0 Pa	248 298 1,0 U	249 299 1,0 Np	250 300 1,0 Pu	251 301 1,0 Am	252 302 1,0 Cm	253 303 1,0 Bk	254 304 1,0 Cf	255 305 1,0 Es	256 306 1,0 Fm	257 307 1,0 Md	258 308 1,0 No	259 309 1,0 Lr	260 310 1,0 Lu	261 311 1,0 Hf	262 312 1,0 Ta	263 313 1,0 W	264 314 1,0 Re	265 315 1,0 Os	266 316 1,0 Pt	267 317 1,0 Au	268 318 1,0 Hg	269 319 1,0 Tl	270 320 1,0 Pb	271 321 1,0 Bi	272 322 1,0 Po	273 323 1,0 At	274 324 1,0 Rn	275 325 1,0 Fr	276 326 1,0 Ra	277 327 1,0 Ac	278 328 1,0 Th	279 329 1,0 Pa	280 330 1,0 U	281 331 1,0 Np	282 332 1,0 Pu	283 333 1,0 Am	284 334 1,0 Cm	285 335 1,0 Bk	286 336 1,0 Cf	287 337 1,0 Es	288 338 1,0 Fm	289 339 1,0 Md	290 340 1,0 No	291 341 1,0 Lr	292 342 1,0 Lu	293 343 1,0 Hf	294 344 1,0 Ta	295 345 1,0 W	296 346 1,0 Re	297 347 1,0 Os	298 348 1,0 Pt	299 349 1,0 Au	300 350 1,0 Hg	301 351 1,0 Tl	302 352 1,0 Pb	303 353 1,0 Bi	304 354 1,0 Po	305 355 1,0 At	306 356 1,0 Rn	307 357 1,0 Fr	308 358 1,0 Ra	309 359 1,0 Ac	310 360 1,0 Th	311 361 1,0 Pa	312 362 1,0 U	313 363 1,0 Np	314 364 1,0 Pu	315 365 1,0 Am	316 366 1,0 Cm	317 367 1,0 Bk	318 368 1,0 Cf	319 369 1,0 Es	320 370 1,0 Fm	321 371 1,0 Md	322 372 1,0 No	323 373 1,0 Lr	324 374 1,0 Lu	325 375 1,0 Hf	326 376 1,0 Ta	327 377 1,0 W	328 378 1,0 Re	329 379 1,0 Os	330 380 1,0 Pt	331 381 1,0 Au	332 382 1,0 Hg	333 383 1,0 Tl	334 384 1,0 Pb	335 385 1,0 Bi	336 386 1,0 Po	337 387 1,0 At	338 388 1,0 Rn	339 389 1,0 Fr	340 390 1,0 Ra	341 391 1,0 Ac	342 392 1,0 Th	343 393 1,0 Pa	344 394 1,0 U	345 395 1,0 Np	346 396 1,0 Pu	347 397 1,0 Am	348 398 1,0 Cm	349 399 1,0 Bk	350 400 1,0 Cf	351 401 1,0 Es	352 402 1,0 Fm	353 403 1,0 Md	354 404 1,0 No	355 405 1,0 Lr	356 406 1,0 Lu	357 407 1,0 Hf	358 408 1,0 Ta	359 409 1,0 W	360 410 1,0 Re	361 411 1,0 Os	362 412 1,0 Pt	363 413 1,0 Au	364 414 1,0 Hg	365 415 1,0 Tl	366 416 1,0 Pb	367 417 1,0 Bi	368 418 1,0 Po	369 419 1,0 At	370 420 1,0 Rn	371 421 1,0 Fr	372 422 1,0 Ra	373 423 1,0 Ac	374 424 1,0 Th	375 425 1,0 Pa	376 426 1,0 U	377 427 1,0 Np	378 428 1,0 Pu	379 429 1,0 Am	380 430 1,0 Cm	381 431 1,0 Bk	382 432 1,0 Cf	383 433 1,0 Es	384 434 1,0 Fm	385 435 1,0 Md	386 436 1,0 No	387 437 1,0 Lr	388 438 1,0 Lu	389 439 1,0 Hf	390 440 1,0 Ta	391 441 1,0 W	392 442 1,0 Re	393 443 1,0 Os	394 444 1,0 Pt	395 445 1,0 Au	396 446 1,0 Hg	397 447 1,0 Tl	398 448 1,0 Pb	399 449 1,0 Bi	400 450 1,0 Po	401 451 1,0 At	402 452 1,0 Rn	403 453 1,0 Fr	404 454 1,0 Ra	405 455 1,0 Ac	406 456 1,0 Th	407 457 1,0 Pa	408 458 1,0 U	409 459 1,0 Np	410 460 1,0 Pu	411 461 1,0 Am	412 462 1,0 Cm	413 463 1,0 Bk	414 464 1,0 Cf	415 465 1,0 Es	416 466 1,0 Fm	417 467 1,0 Md	418 468 1,0 No	419 469 1,0 Lr	420 470 1,0 Lu	421 471 1,0 Hf	422 472 1,0 Ta	423 473 1,0 W	424 474 1,0 Re	425 475 1,0 Os	426 476 1,0 Pt	427 477 1,0 Au	428 478 1,0 Hg	429 479 1,0 Tl	430 480 1,0 Pb	431 481 1,0 Bi	432 482 1,0 Po	433 483 1,0 At	434 484 1,0 Rn	435 485 1,0 Fr	436 486 1,0 Ra	437 487 1,0 Ac	438 488 1,0 Th	439 489 1,0 Pa	440 490 1,0 U	441 491 1,0 Np	442 492 1,0 Pu	443 493 1,0 Am	444 494 1,0 Cm	445 495 1,0 Bk	446 496 1,0 Cf	447 497 1,0 Es	448 498 1,0 Fm	449 499 1,0 Md	450 500 1,0 No	451 501 1,0 Lr	452 502 1,0 Lu	453 503 1,0 Hf	454 504 1,0 Ta	455 505 1,0 W	456 506 1,0 Re	457 507 1,0 Os	458 508 1,0 Pt	459 509 1,0 Au	460 510 1,0 Hg	461 511

TABLE 4A: STANDARD REDUCTION POTENTIALS
TABEL 4A: STANDAARD-REDUKSIEPOTENSIALE

Half-reactions/Halfreaksies	E° (V)
$F_2(g) + 2e^- \rightleftharpoons 2F^-$	+ 2,87
$Co^{3+} + e^- \rightleftharpoons Co^{2+}$	+ 1,81
$H_2O_2 + 2H^+ + 2e^- \rightleftharpoons 2H_2O$	+1,77
$MnO_4^- + 8H^+ + 5e^- \rightleftharpoons Mn^{2+} + 4H_2O$	+ 1,51
$Cl_2(g) + 2e^- \rightleftharpoons 2Cl^-$	+ 1,36
$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightleftharpoons 2Cr^{3+} + 7H_2O$	+ 1,33
$O_2(g) + 4H^+ + 4e^- \rightleftharpoons 2H_2O$	+ 1,23
$MnO_2 + 4H^+ + 2e^- \rightleftharpoons Mn^{2+} + 2H_2O$	+ 1,23
$Pt^{2+} + 2e^- \rightleftharpoons Pt$	+ 1,20
$Br_2(l) + 2e^- \rightleftharpoons 2Br^-$	+ 1,07
$NO_3^- + 4H^+ + 3e^- \rightleftharpoons NO(g) + 2H_2O$	+ 0,96
$Hg^{2+} + 2e^- \rightleftharpoons Hg(l)$	+ 0,85
$Ag^+ + e^- \rightleftharpoons Ag$	+ 0,80
$NO_3^- + 2H^+ + e^- \rightleftharpoons NO_2(g) + H_2O$	+ 0,80
$Fe^{3+} + e^- \rightleftharpoons Fe^{2+}$	+ 0,77
$O_2(g) + 2H^+ + 2e^- \rightleftharpoons H_2O_2$	+ 0,68
$I_2 + 2e^- \rightleftharpoons 2I^-$	+ 0,54
$Cu^+ + e^- \rightleftharpoons Cu$	+ 0,52
$SO_2 + 4H^+ + 4e^- \rightleftharpoons S + 2H_2O$	+ 0,45
$2H_2O + O_2 + 4e^- \rightleftharpoons 4OH^-$	+ 0,40
$Cu^{2+} + 2e^- \rightleftharpoons Cu$	+ 0,34
$SO_4^{2-} + 4H^+ + 2e^- \rightleftharpoons SO_2(g) + 2H_2O$	+ 0,17
$Cu^{2+} + e^- \rightleftharpoons Cu^+$	+ 0,16
$Sn^{4+} + 2e^- \rightleftharpoons Sn^{2+}$	+ 0,15
$S + 2H^+ + 2e^- \rightleftharpoons H_2S(g)$	+ 0,14
$2H^+ + 2e^- \rightleftharpoons H_2(g)$	0,00
$Fe^{3+} + 3e^- \rightleftharpoons Fe$	- 0,06
$Pb^{2+} + 2e^- \rightleftharpoons Pb$	- 0,13
$Sn^{2+} + 2e^- \rightleftharpoons Sn$	- 0,14
$Ni^{2+} + 2e^- \rightleftharpoons Ni$	- 0,27
$Co^{2+} + 2e^- \rightleftharpoons Co$	- 0,28
$Cd^{2+} + 2e^- \rightleftharpoons Cd$	- 0,40
$Cr^{3+} + e^- \rightleftharpoons Cr^{2+}$	- 0,41
$Fe^{2+} + 2e^- \rightleftharpoons Fe$	- 0,44
$Cr^{3+} + 3e^- \rightleftharpoons Cr$	- 0,74
$Zn^{2+} + 2e^- \rightleftharpoons Zn$	- 0,76
$2H_2O + 2e^- \rightleftharpoons H_2(g) + 2OH^-$	- 0,83
$Cr^{2+} + 2e^- \rightleftharpoons Cr$	- 0,91
$Mn^{2+} + 2e^- \rightleftharpoons Mn$	- 1,18
$Al^{3+} + 3e^- \rightleftharpoons Al$	- 1,66
$Mg^{2+} + 2e^- \rightleftharpoons Mg$	- 2,36
$Na^+ + e^- \rightleftharpoons Na$	- 2,71
$Ca^{2+} + 2e^- \rightleftharpoons Ca$	- 2,87
$Sr^{2+} + 2e^- \rightleftharpoons Sr$	- 2,89
$Ba^{2+} + 2e^- \rightleftharpoons Ba$	- 2,90
$Cs^+ + e^- \rightleftharpoons Cs$	- 2,92
$K^+ + e^- \rightleftharpoons K$	- 2,93
$Li^+ + e^- \rightleftharpoons Li$	- 3,05

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TABLE 4B: STANDARD REDUCTION POTENTIALS
TABEL 4B: STANDAARD-REDUKSIEPOTENSIALE

Half-reactions/Halfreaksies	E° (V)
$\text{Li}^{+} + \text{e}^{-} \rightleftharpoons \text{Li}$	- 3,05
$\text{K}^{+} + \text{e}^{-} \rightleftharpoons \text{K}$	- 2,93
$\text{Cs}^{+} + \text{e}^{-} \rightleftharpoons \text{Cs}$	- 2,92
$\text{Ba}^{2+} + 2\text{e}^{-} \rightleftharpoons \text{Ba}$	- 2,90
$\text{Sr}^{2+} + 2\text{e}^{-} \rightleftharpoons \text{Sr}$	- 2,89
$\text{Ca}^{2+} + 2\text{e}^{-} \rightleftharpoons \text{Ca}$	- 2,87
$\text{Na}^{+} + \text{e}^{-} \rightleftharpoons \text{Na}$	- 2,71
$\text{Mg}^{2+} + 2\text{e}^{-} \rightleftharpoons \text{Mg}$	- 2,36
$\text{Al}^{3+} + 3\text{e}^{-} \rightleftharpoons \text{Al}$	- 1,66
$\text{Mn}^{2+} + 2\text{e}^{-} \rightleftharpoons \text{Mn}$	- 1,18
$\text{Cr}^{2+} + 2\text{e}^{-} \rightleftharpoons \text{Cr}$	- 0,91
$2\text{H}_2\text{O} + 2\text{e}^{-} \rightleftharpoons \text{H}_2(\text{g}) + 2\text{OH}^{-}$	- 0,83
$\text{Zn}^{2+} + 2\text{e}^{-} \rightleftharpoons \text{Zn}$	- 0,76
$\text{Cr}^{3+} + 3\text{e}^{-} \rightleftharpoons \text{Cr}$	- 0,74
$\text{Fe}^{2+} + 2\text{e}^{-} \rightleftharpoons \text{Fe}$	- 0,44
$\text{Cr}^{3+} + \text{e}^{-} \rightleftharpoons \text{Cr}^{2+}$	- 0,41
$\text{Cd}^{2+} + 2\text{e}^{-} \rightleftharpoons \text{Cd}$	- 0,40
$\text{Co}^{2+} + 2\text{e}^{-} \rightleftharpoons \text{Co}$	- 0,28
$\text{Ni}^{2+} + 2\text{e}^{-} \rightleftharpoons \text{Ni}$	- 0,27
$\text{Sn}^{2+} + 2\text{e}^{-} \rightleftharpoons \text{Sn}$	- 0,14
$\text{Pb}^{2+} + 2\text{e}^{-} \rightleftharpoons \text{Pb}$	- 0,13
$\text{Fe}^{3+} + 3\text{e}^{-} \rightleftharpoons \text{Fe}$	- 0,06
$2\text{H}^{+} + 2\text{e}^{-} \rightleftharpoons \text{H}_2(\text{g})$	0,00
$\text{S} + 2\text{H}^{+} + 2\text{e}^{-} \rightleftharpoons \text{H}_2\text{S}(\text{g})$	+ 0,14
$\text{Sn}^{4+} + 2\text{e}^{-} \rightleftharpoons \text{Sn}^{2+}$	+ 0,15
$\text{Cu}^{2+} + \text{e}^{-} \rightleftharpoons \text{Cu}^{+}$	+ 0,16
$\text{SO}_4^{2-} + 4\text{H}^{+} + 2\text{e}^{-} \rightleftharpoons \text{SO}_2(\text{g}) + 2\text{H}_2\text{O}$	+ 0,17
$\text{Cu}^{2+} + 2\text{e}^{-} \rightleftharpoons \text{Cu}$	+ 0,34
$2\text{H}_2\text{O} + \text{O}_2 + 4\text{e}^{-} \rightleftharpoons 4\text{OH}^{-}$	+ 0,40
$\text{SO}_2 + 4\text{H}^{+} + 4\text{e}^{-} \rightleftharpoons \text{S} + 2\text{H}_2\text{O}$	+ 0,45
$\text{Cu}^{+} + \text{e}^{-} \rightleftharpoons \text{Cu}$	+ 0,52
$\text{I}_2 + 2\text{e}^{-} \rightleftharpoons 2\text{I}^{-}$	+ 0,54
$\text{O}_2(\text{g}) + 2\text{H}^{+} + 2\text{e}^{-} \rightleftharpoons \text{H}_2\text{O}_2$	+ 0,68
$\text{Fe}^{3+} + \text{e}^{-} \rightleftharpoons \text{Fe}^{2+}$	+ 0,77
$\text{NO}_3^{-} + 2\text{H}^{+} + \text{e}^{-} \rightleftharpoons \text{NO}_2(\text{g}) + \text{H}_2\text{O}$	+ 0,80
$\text{Ag}^{+} + \text{e}^{-} \rightleftharpoons \text{Ag}$	+ 0,80
$\text{Hg}^{2+} + 2\text{e}^{-} \rightleftharpoons \text{Hg}(\text{l})$	+ 0,85
$\text{NO}_3^{-} + 4\text{H}^{+} + 3\text{e}^{-} \rightleftharpoons \text{NO}(\text{g}) + 2\text{H}_2\text{O}$	+ 0,96
$\text{Br}_2(\text{l}) + 2\text{e}^{-} \rightleftharpoons 2\text{Br}^{-}$	+ 1,07
$\text{Pt}^{2+} + 2\text{e}^{-} \rightleftharpoons \text{Pt}$	+ 1,20
$\text{MnO}_2 + 4\text{H}^{+} + 2\text{e}^{-} \rightleftharpoons \text{Mn}^{2+} + 2\text{H}_2\text{O}$	+ 1,23
$\text{O}_2(\text{g}) + 4\text{H}^{+} + 4\text{e}^{-} \rightleftharpoons 2\text{H}_2\text{O}$	+ 1,23
$\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^{+} + 6\text{e}^{-} \rightleftharpoons 2\text{Cr}^{3+} + 7\text{H}_2\text{O}$	+ 1,33
$\text{Cl}_2(\text{g}) + 2\text{e}^{-} \rightleftharpoons 2\text{Cl}^{-}$	+ 1,36
$\text{MnO}_4^{-} + 8\text{H}^{+} + 5\text{e}^{-} \rightleftharpoons \text{Mn}^{2+} + 4\text{H}_2\text{O}$	+ 1,51
$\text{H}_2\text{O}_2 + 2\text{H}^{+} + 2\text{e}^{-} \rightleftharpoons 2\text{H}_2\text{O}$	+ 1,77
$\text{Co}^{3+} + \text{e}^{-} \rightleftharpoons \text{Co}^{2+}$	+ 1,81
$\text{F}_2(\text{g}) + 2\text{e}^{-} \rightleftharpoons 2\text{F}^{-}$	+ 2,87

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QUESTION 4.3

