

Name _____

Index No. _____/_____

9518/1

CHEMISTRY

Paper 1

D.T.E.

March/April 2014

Time: 3 hours

Candidate's Signature _____

Date _____



THE KENYA NATIONAL EXAMINATIONS COUNCIL

DIPLOMA IN TEACHER EDUCATION

CHEMISTRY

Paper 1

3 hours

INSTRUCTIONS TO CANDIDATES

Write your name and index number in the spaces provided above.

Sign and write the date of the examination in the spaces provided above.

This paper consists of **THREE** sections; Section A, General Chemistry, Section B, Physical Chemistry and Section C, Inorganic Chemistry.

Answer **ALL** the questions in section A, B and C in the spaces provided.

Electronic calculators may be used.

A copy of the periodic table is provided at the end of the paper.

Candidates should answer the questions in English.

For Examiner's Use Only

Section	Question	Maximum Score	Candidate's Score
A	1	10	
	2	10	
B	3	15	
	4	17	
	5	15	
	6	13	
C	7	13	
	8	14	
	9	13	
Total Score			

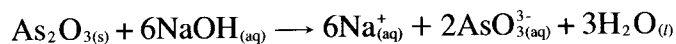
This paper consists of 22 printed pages.

Candidates should check the question paper to ascertain that all the pages are printed as indicated and that no questions are missing.

SECTION A: (20 marks)

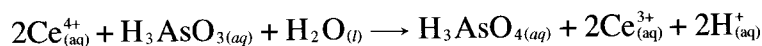
Answer ALL the questions in this section.

1. (a) An oxide of arsenic reacts with sodium hydroxide as shown in the following equation:



What property of arsenic oxide makes it behave as shown? (1 mark)

- (b) Cerium (IV) ions react as shown below:



- (i) What is the oxidation number of arsenic in the:

(I) reactants; ($\frac{1}{2}$ mark)

(II) products. ($\frac{1}{2}$ mark)

- (ii) 0.126g sample of arsenic acid reacts completely with 20.0 cm³ of Ce⁴⁺ solution.
Calculate the concentration of the Ce⁴⁺ solution in moles per litre. (2 marks)

- (c) (i) Explain using Bohr's atomic model why an electron in a hydrogen atom does not fall into the nucleus. (1 mark)

- (ii) State the success of the Bohr model of the atom. (1 mark)

- (d) Figure 1 shows the first three lines of the Balmer series of the hydrogen atom spectrum.

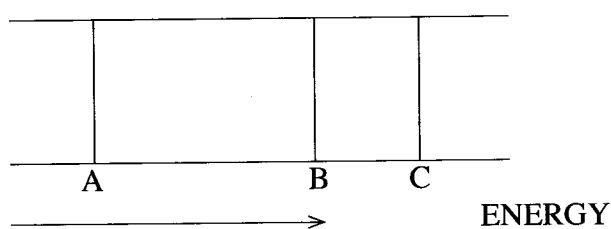


Figure 1

- (i) Using the energy level diagram in figure 2, draw and label arrows to indicate the electron transitions that corresponds to the lines labelled A, B and C in figure 1.

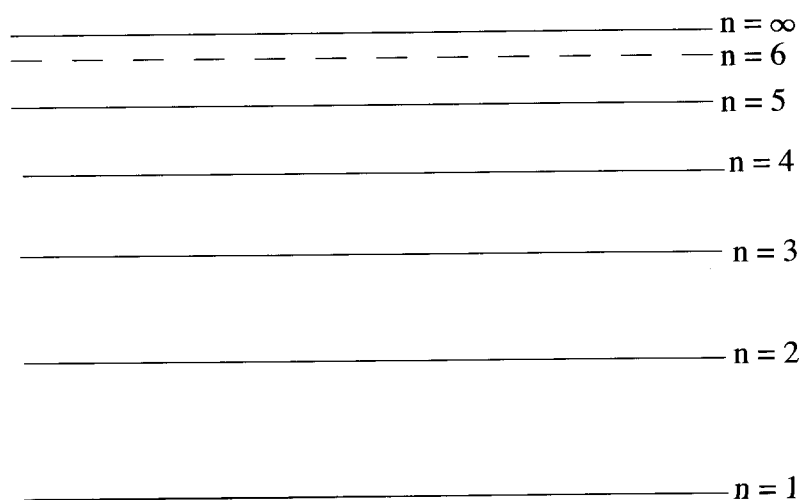


Figure 2

(1½ marks)

- (ii) State what happens to a hydrogen atom when an electron moves from $n = 1$ to $n = \infty$. ($\frac{1}{2}$ mark)

- (e) The solution of the schrodinger wave equation yields four quantum numbers. Complete the following table by indicating the significance of each.

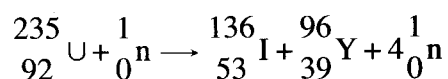
Quantum numbers	Significance
n	
l	
m_l	
m_s	

(2 marks)

2. (a) One of the differences between chemical reactions and nuclear reactions is that nuclear reactions are accompanied by very high energy changes.

- (i) State **two** other differences between nuclear and chemical reactions. (2 marks)

- (ii) Calculate the energy change in kJmol^{-1} for the following nuclear reaction.



The masses of the nuclei are:

$${}_{53}^{136}\text{I} = 135.8401; {}_{39}^{96}\text{Y} = 95.8629; {}_{92}^{235}\text{U} = 234.995$$

The mass of the neutron is 1.00867 and the speed of light is $2.998 \times 10^8 \text{ ms}^{-1}$. (2 marks)

- (iii) Describe how the radioisotope iodine-131 is used in the diagnosis of goitre. (2 marks)

- (b) Using valence shell electron pair repulsion (VSEPR) theory, give and explain the shapes of the following molecules and indicate the bond angle in each.

- (i) PCl_3 (1 $\frac{1}{2}$ marks)

- (ii) BCl_3 (1 $\frac{1}{2}$ marks)

- (iii) Sketch the structure of the compound formed when PCl_3 and BCl_3 combine.
Name the type of bond formed in the molecule. (1 mark)

SECTION B (60 marks)

Answer ALL the questions in this section.

3. (a) Using the first law of thermodynamics and the relation, $H = E + PV$, show that at constant pressure, the enthalpy change is equal to the heat absorbed in a chemical change. (3 marks)

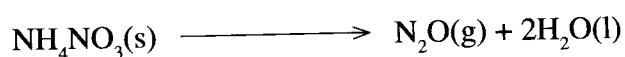
- (b) (i) Explain why the value of enthalpy of formation of carbon (IV) oxide at 25°C is different from its value at 100°C . (2 marks)

- (ii) The standard enthalpies of combustion of carbon and carbon (II) oxide are $-393.5 \text{ kJ mol}^{-1}$ and $-283.0 \text{ kJ mol}^{-1}$ respectively. Calculate the molar enthalpy of formation of carbon (II)oxide at:

(I) constant pressure; (2 marks)

(II) constant volume. (2 marks)
($R = 8.314 \text{ kJ mol}^{-1}$)

- (c) (i) Ammonium nitrate decomposes according to the following equation.



State and explain the sign of entropy change. (2 marks)

- (ii) The work done in a reversible isothermal expansion of an ideal gas is given by $w = -nRT \ln \left(\frac{V_f}{V_i} \right)$ where V_i and V_f are the initial and final volumes respectively. Derive an expression for entropy change for the expansion. (2 marks)

- (iii) Calculate the entropy change when 0.2 moles of an ideal gas expands isothermally from 20 dm³ to 50 dm³. ($R = 8.314 \text{ JK}^{-1}\text{mol}^{-1}$) (2 marks)

4. (a) The phase rule expressed in terms of degrees of freedom (F), is as follows:

$$F = C + 2 - P.$$

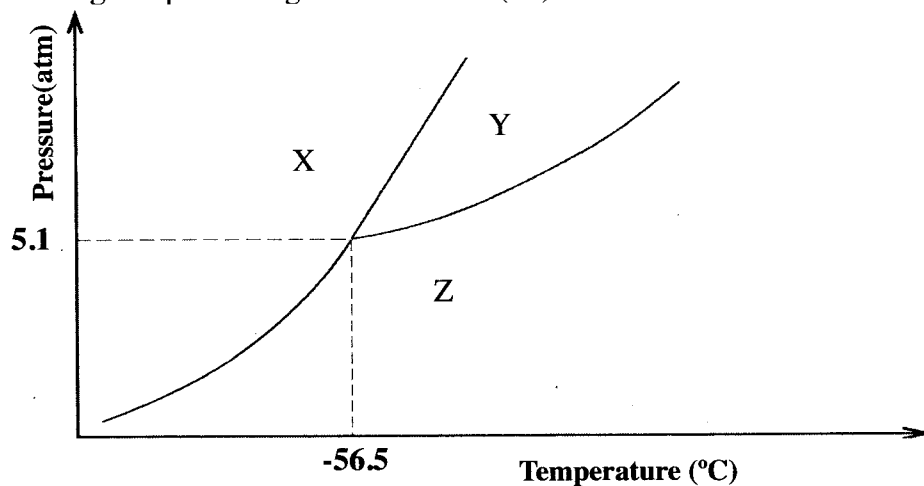
where P = number of phases

C = number of components.

- (i) Explain what is meant by the term 'degrees of freedom'. (1 mark)

- (ii) Determine the value of F at the triple point of water. (1 mark)

- (b) The following is a phase diagram for carbon (IV) oxide.



- (i) Label the phases represented by the letters X, Y and Z. (2 marks)

- (ii) Use the diagram to determine how an increase in pressure affects the melting point of carbon (IV) oxide. (1 mark)

- (iii) Explain why liquid carbon (IV) oxide does not exist at standard pressure. (2 marks)

- (c) Two students were each provided with 20 cm³ of an organic solvent to extract benzoic acid from 10 cm³ of an aqueous solution. The first student used all the 20 cm³ of the organic solvent at once while the second student used two 10 cm³ portions of the organic solvent.

- (i) State and explain which extraction was more effective. (1 mark)

- (ii) If a student wished to extract benzoic acid using tetrachloromethane, explain how benzoic acid is partitioned between the aqueous and organic layers. (3 marks)

- (iii) Used oil is contaminated with metal salts. Explain how the salts can be removed from the used oil. (2 marks)

- (d) Calcium hydroxide dissolves with evolution of heat. Its solubility product is $5.5 \times 10^{-6} \text{ mol}^3 \text{ dm}^{-9}$ at 25°C .

- (i) Calculate the solubility of calcium hydroxide in moles per litre at 25°C . (2 marks)

- (ii) Explain how the solubility of calcium hydroxide will be affected by a decrease in temperature. (2 marks)

5. (a) Consider the following half cells and their standard reduction potentials

		E^θ / V
I	$\text{Fe}_{(\text{aq})}^{2+} / \text{Fe}_{(\text{s})}$	-0.44
II	$\text{Pt}_{(\text{s})} / \text{Sn}_{(\text{aq})}^{4+}, \text{Sn}_{(\text{aq})}^{2+}$	+0.14
III	$\text{Pt}_{(\text{s})} / \text{Cl}_{2(\text{g})}, \text{Cl}_{(\text{aq})}^-$	+1.36
IV	$\text{Ag}_{(\text{s})} / \text{AgCl}_{(\text{s})} / \text{Cl}_{(\text{aq})}^-$	+0.22

- (i) State the type of electrodes in half cell:

II:

(1 mark)

IV:

(1 mark)

- (ii) Draw a diagram of an electrochemical cell with the highest e.m.f value from the half cells provided. (3 marks)

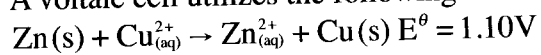
- (b) (i) Use the following **two** expressions for change in free energy to derive the Nernst equation; $E = E^\theta - \frac{0.059}{n} \log K$, at 25 °C. (3 marks)

$$\Delta G = -nFE$$

$$\Delta G = \Delta G^\theta + 2.303 RT \log K.$$

$$(F = 96500 \text{ C}, R = 8.314 \text{ J mol}^{-1} \text{ K}^{-1})$$

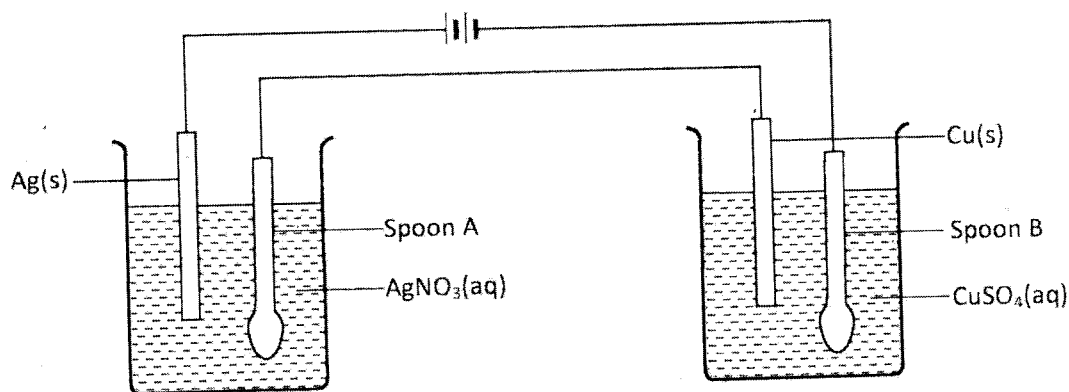
- (ii) A voltaic cell utilizes the following reaction:



Calculate the e.m.f of this cell at 298 K when
 $[\text{Cu}^{2+}] = 1.50 \text{ M}$ and $[\text{Zn}^{2+}] = 0.045 \text{ M}$.

(3 marks)

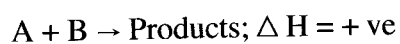
- (c) The following set-up was used to electroplate two iron spoons, one with copper and the other with silver.



- (i) State **two** conditions which should be considered in order to obtain uniform coating on the iron spoon. (2 marks)

- (ii) The initial mass of each spoon was 12.56 g. At the end of the process, the mass of spoon B coated with copper was 17.13 g. Calculate the mass of spoon A that was coated with silver. (2 marks)

6. (a) For the reaction:



(i) Sketch and label the energy versus reaction pathway diagram. (2 marks)

(ii) With reference to the diagram in (a) (i), explain how the following affect the rate of the reaction:

(I) presence of a catalyst; (2 marks)

(II) decrease in temperature. (2 marks)

- (b) In an experiment to study the acid catalysed reaction of propanone with iodine, 50 cm³ of 0.05 M iodine solution was mixed with 50 cm³ of acidified 0.25 M propanone solution. 10 cm³ portions of the reaction mixture were removed at intervals of 5 minutes and quenched. These portions were titrated with 0.04 M sodium thiosulphate using starch indicator.

(i) State **one** method that would be used to quench the reaction. (1 mark)

(ii) Write an ionic equation for the reaction of sodium thiosulphate and iodine. (1 mark)

(iii) If the rate of consumption of iodine was found to be constant, what is the order of reaction with respect to iodine? Explain. (1 mark)

(iv) For the reaction: $\text{CH}_3\text{COCH}_3(\text{aq}) + \text{I}_2(\text{aq}) \rightarrow \text{CH}_3\text{CICOCH}_3(\text{aq}) + \text{H}^+(\text{aq}) + \text{I}^-(\text{aq})$

The rate of consumption of iodine is $2.00 \times 10^{-5} \text{ mol dm}^{-3} \text{ min}^{-1}$. What is the rate of consumption of propanone? (1 mark)

(v) Calculate the number of moles of iodine after 20 minutes of reaction. (2 marks)

- (vi) The reaction is first order with respect to propanone. If 0.5 mol dm^{-3} propanone were used in place of 0.25 mol dm^{-3} , what would be the rate of reaction. (1 mark)

SECTION C (40 marks)

Answer **ALL** the questions in this section.

7. (a) The melting points of period three elements are given below:

Element	Na	Mg	Al	Si	P	S	Cl	Ar
M.p. ($^{\circ}\text{C}$)	98	650	660	1410	44 (white)	119 (rhombic)	-101	-189

- (i) Explain the trends in melting points from:

(I) Na to Al;

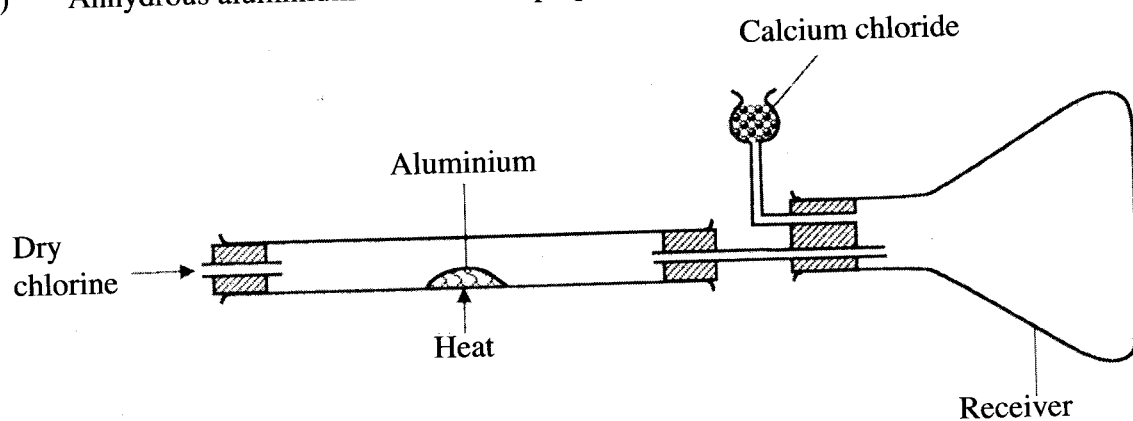
(2 marks)

(II) P to Ar.

(2 marks)

- (ii) Sketch the structure of silicon and use it to explain the high melting point of silicon. (2 marks)

- (b) Anhydrous aluminium chloride was prepared as shown in the set-up below.



- (i) State the observations that were made during the reaction. (2 marks)
-
-
- (ii) State the purpose of calcium chloride in the set-up. (1 mark)
-
-
- (iii) Starting with 3.4 g of aluminium, a student obtained 15.2 g of the chloride. Determine the percentage yield. (2 marks)
-
-
-
-

- (c) A bottle containing silicon (IV) chloride fumes strongly on opening in air. Explain this observation using an equation. (2 marks)

8. (a) Explain the following observations:

- (i) successive ionisation energies of an element increase in the order:

$$1^{\text{st}} < 2^{\text{nd}} < 3^{\text{rd}}$$

(2 marks)

- (ii) the first electron affinity of an oxygen atom is exothermic while the second one is endothermic. (2 marks)

(iii) acidity of the hydrogen halides decreases as follows:



(2 marks)

(b) The following are bond dissociation energies of the halogens.

Halogen	Bond dissociation energy (kJmol^{-1})
Fluorine	158
Chlorine	242
Bromine	193
Iodine	151

(i) Explain the general trend in the bond dissociation energies.

(1 mark)

(ii) Give a reason for the anomalous value for fluorine.

(1 mark)

(iii) Apart from bond dissociation energies, what other factors influence the reactivity of fluorine compared to that of iodine?

(2 marks)

(c) Concentrated sulphuric (VI) acid is heated with rock salt to prepare hydrogen chloride.

(i) Write an equation for the reaction. (1 mark)

(ii) Explain why a similar method is not suitable for preparation of hydrogen iodide. (1 mark)

(d) Explain how a solution containing lead(II) ions can be used to distinguish between aqueous chloride ions and aqueous iodide ions. (2 marks)

9. (a) Consider the following two chromium compounds.

A: $[\text{Cr}(\text{NH}_3)_5\text{SO}_4]\text{Br}$.

B: $[\text{Cr}(\text{NH}_3)_5\text{Br}]\text{SO}_4$.

(i) Write the electronic configuration of chromium in compound A. (1 mark)

(ii) Name compound A. (1 mark)

(iii) Determine the coordination number of chromium in compound A. (1 mark)

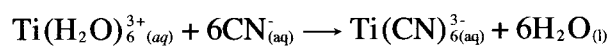
(iv) Explain how electrical conductivity can be used to distinguish between compounds A and B. (2 marks)

- (b) Study the following table and use it to answer the questions that follow.

Wavelength (nm)	Colour absorbed	Colour observed
400 - 430	violet	yellow
430 - 490	blue	orange
490 - 560	green	red
560 - 580	yellow	violet
580 - 650	orange	blue

- (i) Determine the wavelength range at which $\text{Cu}_{(\text{aq})}^{2+}$ ions absorb: (1 mark)

- (ii) The following reaction is known to occur:



- (I) What name is given to this type of reaction? (1 mark)

- (II) $\text{Ti}(\text{H}_2\text{O})_6^{3+}$ ions absorb at 510 nm while $\text{Ti}(\text{CN})_6^{3-}$ ions absorb at 438 nm. State the observations that would be made during the reaction. (1 mark)

- (III) Explain why the complexes $\text{Ti}(\text{H}_2\text{O})_6^{3+}$ and $\text{Ti}(\text{CN})_6^{3-}$ absorb at different wavelengths. (2 marks)

(c) Give **one** use of each of the following:

(i) Titanium in medicine;

(ii) Chromium in motor vehicle industry;

(iii) Copper in agriculture.

(3 marks)

Periodic Table of the Elements

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Periodic Table of the Elements

<http://chemistry.about.com>
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1A	1 H 1.00794	2A	4 Be 9.012182	3B	21 Sc 44.955912	4B	22 Ti 47.867	5B	23 V 50.9415	6B	24 Cr 51.9961	7B	25 Mn 54.938045	8B	26 Fe 55.845	27 Co 58.933195	28 Ni 58.6934	1B	29 Cu 63.546	2B	30 Zn 65.38	31 Ga 69.723	32 Ge 72.64	33 As 74.92160	34 Se 78.96	35 Br 79.904	36 Kr 83.798	37 Rb 85.4678	38 Sr 87.62	39 Y 88.90585	40 Zr 91.224	41 Nb 92.90638	42 Mo 95.96	43 Tc [98]	44 Ru 101.07	45 Rh 102.90550	46 Pd 106.42	47 Ag 107.8682	48 Cd 112.411	49 In 114.818	50 Sn 118.710	51 Sb 121.760	52 Te 127.60	53 I 126.90447	54 Xe 131.293	55 Cs 132.9054519	56 Ba 137.327	Lanthanides 57-71	72 Hf 178.49	73 Ta 180.94788	74 W 183.84	75 Re 186.207	76 Os 190.23	77 Ir 192.217	78 Pt 195.084	79 Au 196.966569	80 Hg 200.59	81 Tl 204.3833	82 Pb 207.2	83 Bi 208.98040	84 Po [209]	85 At [210]	86 Rn [222]	87 Fr 223	88 Ra [226]	Actinides	104 Rf [261]	105 Db [268]	106 Sg [271]	107 Bh [272]	108 Hs [279]	109 Mt [279]	110 Ds [281]	111 Rg [280]	112 Uub [285]	113 Uut [284]	114 Uuq [289]	115 Uup [289]	116 Uuh [289]	117 Uus [294]	118 Uuo [294]
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Lanthanides

Actinides

57 La 138.90547	58 Ce 140.116	59 Pr 140.90765	60 Nd 144.242	61 Pm [145]	62 Sm 150.36	63 Eu 151.964	64 Gd 157.25	65 Tb 158.92535	66 Dy 162.500	67 Ho 164.93032	68 Er 167.259	69 Tm 168.93421	70 Yb 173.054	71 Lu 174.9668
89 Ac [227]	90 Th 232.03806	91 Pa 231.03588	92 U 238.02891	93 Np [237]	94 Pu [244]	95 Am [243]	96 Cm [247]	97 Bk [247]	98 Cf [251]	99 Es [252]	100 Fm [257]	101 Md [258]	102 No [259]	103 Lr [262]

8A

3A 4A 5A 6A 7A

2
He
4.002602

5
B
10.811 6 C 12.0107 | 7 N 14.0067 | 8 O 15.9994 | 9 F 18.9984032 | 10 Ne 20.1797 |

13
Al
10.811 14 Si 12.0107 | 15 P 14.0067 | 16 S 15.9994 | 17 Cl 18.9984032 | 18 Ar 20.1797 |

31
Ga
69.723 32 Ge 72.64 | 33 As 74.92160 | 34 Se 78.96 | 35 Br 79.904 | 36 Kr 83.798 |

49
In
114.818 50 Sn 118.710 | 51 Sb 121.760 | 52 Te 127.60 | 53 I 126.90447 | 54 Xe 131.293 |

81
Tl
204.3833 82 Pb 207.2 | 83 Bi 208.98040 | 84 Po [209] | 85 At [210] | 86 Rn [222] |

113
Uut
[284] 114 Uuq [289] | 115 Uup [289] | 116 Uuh [289] | 117 Uus [294] | 118 Uuo [294] |

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