



Province of the
EASTERN CAPE
EDUCATION

**NATIONAL
SENIOR CERTIFICATE**

GRADE 11

NOVEMBER 2019

TECHNICAL SCIENCES P2

MARKS: 150

TIME: 3 hours



★ I T S C E 2 ★

This question paper consists of pages 14, including 2 data sheets.

INSTRUCTIONS AND INFORMATION

Read the following instructions carefully before answering the questions

1. Write your FULL NAME and SURNAME in the appropriate spaces on the ANSWER BOOK.
2. Answer ALL the questions.
3. Start each question on a NEW page in the ANSWER BOOK.
4. You may use a non-programmable calculator.
5. Appropriate mathematical instruments may be used.
6. Number the answers correctly according to the numbering system used in this question paper.
7. Show ALL formulae and substitutions in ALL calculations.
8. Round off your final numerical answers to a minimum of TWO decimal places.
9. Give brief motivations, discussions et cetera where required.
10. A data sheet and a periodic table are attached for your use.
11. Write neatly and legibly.

QUESTION 1: MULTIPLE-CHOICE QUESTIONS

Various options are provided as possible answers to the following questions. Choose the correct answer and write the letter (A–D) of your choice in the ANSWER BOOK, eg. 1.11 C

1.1 The distance between any two consecutive points in a wave motion that are in phase, is known as a/an ...

- A period.
- B amplitude.
- C oscillation.
- D wavelength.

(2)

1.2 Which ONE of the following statements about a longitudinal wave is CORRECT?

- A The particles of the medium vibrate parallel to the direction of propagation of the pulse
- B The particles of the medium vibrate opposite to the direction of propagation of the pulse
- C The particles of the medium vibrate in the same direction of propagation as the pulse
- D The particles of the medium vibrate at a right angle to the direction of propagation of the pulse

(2)

1.3 What is the SI unit of speed?

- A Joule
- B Hertz
- C Metres per second
- D Metre

(2)

1.4 The number of vibrations to complete a wave in one second is known as the:

- A time interval.
- B frequency.
- C period.
- D oscillation.

(2)

1.5 A transverse wave is generated in a rope by shaking one end of the rope and its wavelength is (λ). The same rope is then shaken in the same way but this time at twice the rate. What will be the comparison of this new wavelength to the previous one?

- A λ
- B $\frac{1}{2} \lambda$
- C 2λ
- D 4λ

(2)

1.6 Bats detect the obstacles in their path by using the following type of wave:

- A Ultrasound
- B Radio waves
- C Electromagnetic waves
- D Infrasound

(2)

1.7 Specific heat capacity is ...

- A the amount of heat required to boil 1 litre of water to 100 °C.
- B the amount of heat required for a refrigerator to maintain a temperature of -4 °C.
- C the amount of heat required to increase the temperature of a substance of 1 kg by 1 °C.
- D the amount of heat required to decrease the temperature of a 1 kg substance by 2 °C every second.

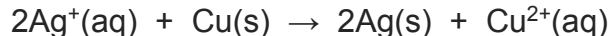
(2)

1.8 Which ONE of the following combinations contains thermodynamic variables?

- A Kinetic energy, temperature and pressure
- B Heat, internal energy and external energy
- C Temperature, pressure and volume
- D Heat, energy and work

(2)

1.9 Consider the reaction represented by the following equation:



Which ONE of the following represents the oxidising agent in the above reaction?

- A Ag^+
- B Ag
- C Cu
- D Cu^{2+}

(2)

1.10 A reducing agent is a substance that undergoes ...

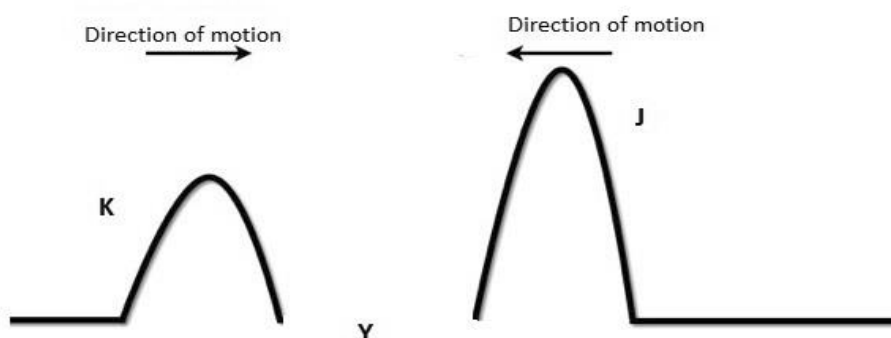
- A reduction and gains electrons in the process.
- B reduction and loses electrons in the process.
- C oxidation and loses electrons in the process.
- D oxidation and gains electrons in the process.

(2)

[20]

QUESTION 2 (Start on a new page)

The diagram below represents two pulses, **K** and **J**, with an amplitude of 3 cm and 6 cm respectively, approaching each other.

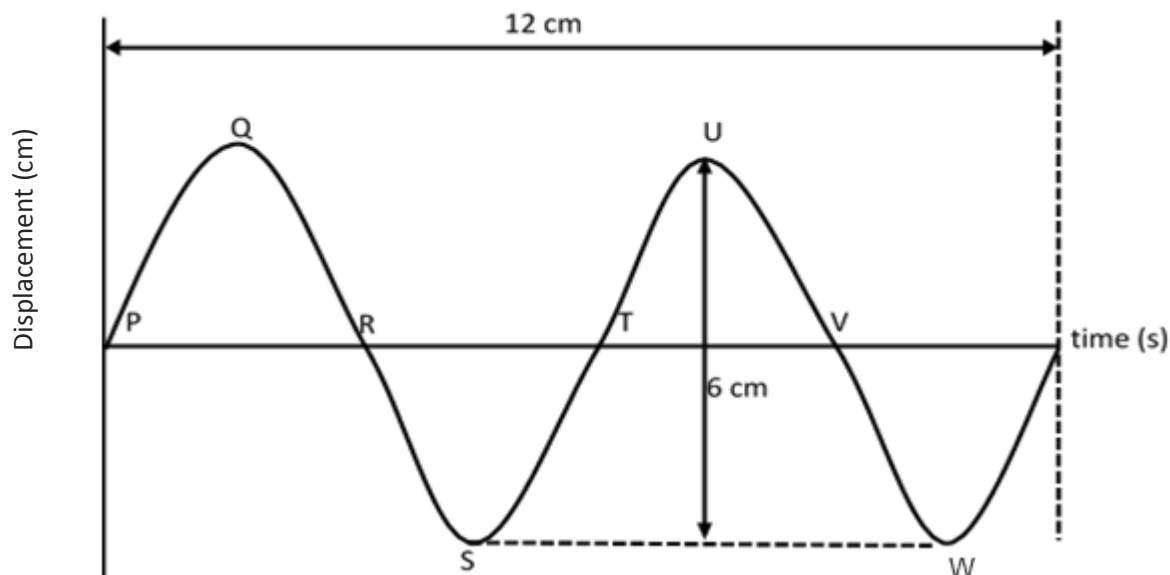


- 2.1 Define the term *transverse wave*. (2)
- 2.2 Draw a labelled diagram of the resulting pulse at point **Y**, when the two pulses meet. (2)
- 2.3 NAME and DEFINE the phenomenon that occurs at point **Y**. (3)
- 2.4 Indicate whether the two pulses will meet in phase or out of phase. Explain your answer. (3)
- 2.5 Consider another scenario in which the SAME two pulses **K** and **J** will meet at point **Y**, but pulse **J** is moving on the OPPOSITE SIDE of the REST POSITION.
 - 2.5.1 Define the term *Amplitude of a wave*. (2)
 - 2.5.2 Write down the magnitude of the resulting AMPLITUDE of the two pulses after they meet at point **Y**. (2)
 - 2.5.3 In which direction will pulse **J** be moving after passing point **Y**? Write down only TO THE LEFT or TO THE RIGHT (2)
 - 2.5.4 Briefly describe the situation of pulse **K** after passing pulse **J** with reference to its **Amplitude** and its **Direction**. (4)

[20]

QUESTION 3 (Start on a new page)

The graph below represents the displacement of particles of a wave versus time. The time taken to complete one wave is 0,3 s.

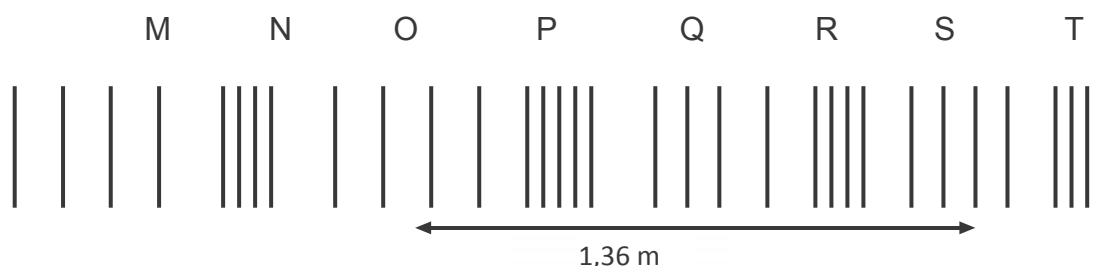


- 3.1 How many complete waves can be represented in 0,6 s in the graph above? (2)
- 3.2 Write down any TWO points that are out of phase in the graph. (2)
- 3.3 Write down any TWO points that are in phase in the graph. (2)
- 3.4 How long will it take to complete five full waves for the graph above? (2)
- 3.5 Name what is represented by the following:
- 3.5.1 Point **Q** and point **S** in the graph above. (2)
- 3.5.2 The line represented by the following points: **P**, **R**, **T** and **V**. (1)
- 3.6 Determine the following in the graph above:
- 3.6.1 Amplitude (2)
- 3.6.2 Wavelength (2)
- 3.7 Calculate the speed of this wave. (4)

[19]

QUESTION 4 (Start on a new page)

The pattern of a sound wave, with frequency 500 Hz, is shown below.

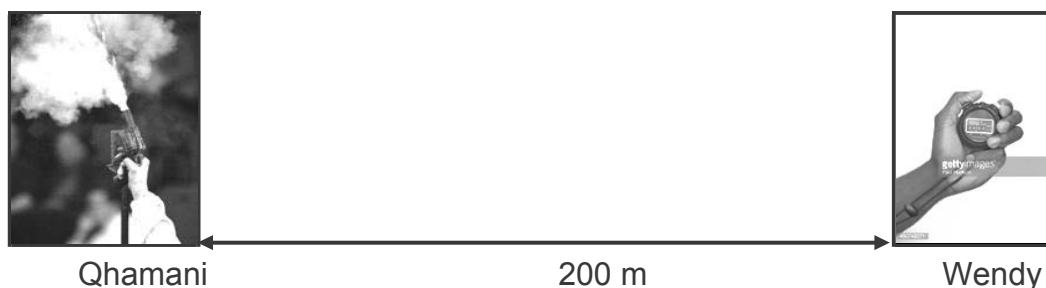


- 4.1 Why is a sound wave defined as a longitudinal wave? (2)
- 4.2 Use the letters in the diagram to indicate the following:
- 4.2.1 A compression (1)
- 4.2.2 A wavelength (1)
- 4.2.3 A rarefaction (1)
- 4.3 Define the *period of a wave*. (2)
- 4.4 Calculate the following for this sound wave:
- 4.4.1 The period (2)
- 4.4.2 The wavelength (2)
- 4.4.3 The speed (2)
- 4.5 Based on your answer to QUESTION 4.4.3, what medium was this sound wave travelling in? (2)
- 4.6 A girl standing between two high cliffs, **A** and **B**, notices that when she claps her hands, she hears the echo off cliff **A** after **1,5 s** and the echo off cliff **B** after **2 s**. Take the speed of sound in air to be **330 m • s⁻¹**.
- 4.6.1 Calculate the distance between the girl and cliff **A**. (2)
- 4.6.2 Calculate the distance between the two cliffs. (3)
- 4.6.3 Explain why the echoes the girl hears are quieter than her original clap. (2)
- 4.7 Define the meaning of the term *echo*. (2)
- 4.8 Write down the following:
- 4.8.1 THREE uses of ultrasound waves (3)
- 4.8.2 TWO uses of infrasound waves (2)

[29]

QUESTION 5 (Start on a new page)

The picture below shows learners conducting an experiment to determine the speed of sound in the air. Qhamani fired the shot with the starter's pistol. Wendy started the stopwatch the instant she saw the smoke and stopped the stopwatch the instant she heard the sound of the shot. The experiment was repeated three times by the same learners. The average time recorded was 0.6s.



- 5.1 Write down TWO safety precautions when conducting this experiment. (2)
- 5.2 Why does each learner have to carry the same role when this experiment is being repeated? (1)
- 5.3 Use the information above to calculate the speed of sound in air. (3)
- 5.4 If the distance between the learners is doubled, will this change affect the answer to QUESTION 5.3 above? Explain your answer. (3)

[9]

QUESTION 6 (Start on a new page)

Thermodynamics deals with processes that involve heat, work and energy. Temperature has something to do with energy, as we can see from the fact that hot steam can lift a piston, and the hotter the steam, the better it is able to perform the work.

- 6.1 What is meant by the term *working substance*? (2)
- 6.2 Give TWO examples of working substance. (2)
- 6.3 State the Law of conservation of heat in words. (2)
- [6]**

QUESTION 7 (Start on a new page)

Today we consume energy in vast quantities, mostly by burning fossil fuels or by using electricity derived primarily from fossil fuels and hydroelectric sources. Industrial consumers create a high demand for electricity.

- 7.1 Differentiate between a thermally closed system and a thermally isolated system. (4)
- 7.2 Which ONE, water or ethyl alcohol (ethanol), can be used as an excellent coolant? Explain your answer by referring to the specific heat capacities of the two substances. (2)
- 7.3 A system absorbs 1 500 J of heat from its surroundings and performs 2 200 J of work on its surroundings. Determine the change in the internal energy of the system. (3)
- 7.4 A container with a certain unknown mass of water at 15 °C is mixed with 100 g of water at 85 °C. The final mixture registers a temperature of 30 °C. Calculate the unknown mass of water in the mixture. (4)
- 7.5 A block of iron (mass 100 g) is heated in an oven to 227 °C and then plunged into a closed, thermally insulated container of 500 g of water at 19 °C. The block and the water come to an equilibrium temperature of 24 °C.
- What is the specific heat of iron, C_{fe} ? Assume that the specific heat of water and iron do not vary significantly over the temperature ranges in question. (6)
- [19]**

QUESTION 8 (Start on a new page)

Electrochemistry is the branch in Technical Sciences that deals with the relationship between electrical and chemical phenomena.

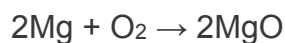
8.1 Distinguish between a *cation* and an *anion*. (4)

8.2 Determine the oxidation numbers to each of the following underlined elements. Write down every step which will show how you arrived at your answer.

8.2.1 $\underline{\text{K}_2}\text{S}$ (2)

8.2.2 $\text{K}\underline{\text{Mn}}\text{O}_4$ (2)

8.3 Consider the following balanced chemical reaction:

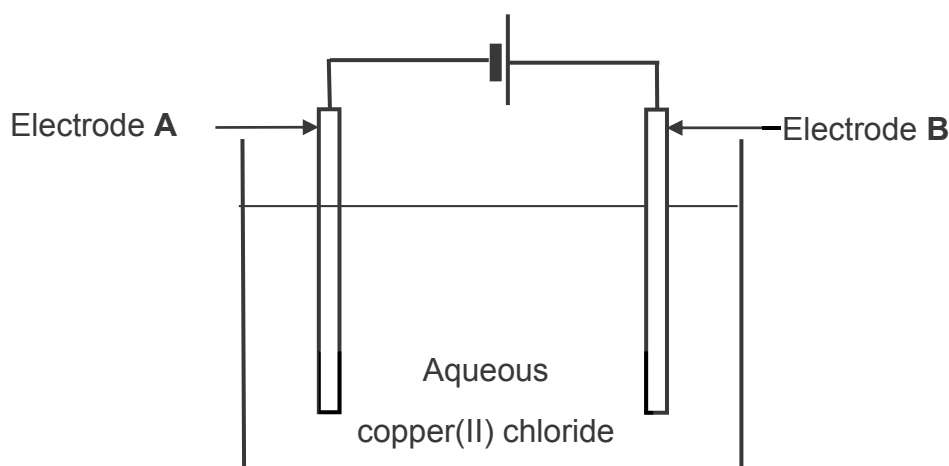


Identify the substance which is:

8.3.1 Oxidised (2)

8.3.2 Reduced (2)

8.4 The experimental set-up shown below was used by an educator to demonstrate the electrolysis of a copper chloride solution ($\text{CuCl}_2(\text{aq})$)



8.4.1 Define the term *electrolysis* in words. (2)

8.4.2 Why are carbon electrodes preferred for this experiment? (2)

8.4.3 What experimental observations will be made at electrodes **A** and **B**? (4)

8.5 Which ONE electrode is the:

8.5.1 Anode (1)

8.5.2 Cathode (1)

8.6 For this electrolytic cell in operation:

8.6.1 Write down the half reaction that will take place at electrode **A**. (2)

8.6.2 Write down the half reaction that will take place at electrode **B**. (2)

8.7 State TWO uses of electrolysis in Technology. (2)

[28]

TOTAL: 150

**DATA FOR TECHNICAL SCIENCES GRADE 11
PAPER 2**

**GEGEWENS VIR TEGNIESE WETENSKAPPE GRAAD 11
VRAESTEL 2**

TABLE 1: SPECIFIC HEAT CAPACITIES/TABEL 1: SPESIFIEKE HITTEKAPASITEITE

| Name/ <i>Naam</i> | Values/ <i>Waardes</i> (J.kg ⁻¹ .K ⁻¹) |
|---|---|
| Water | 4 200 |
| Copper / <i>Koper</i> | 400 |
| Aluminium | 900 |
| Glass / <i>Glas</i> | 700 |
| Ethyl alcohol / <i>Etielalkohol</i> | 2 460 |
| Iron / <i>Yster</i> | 460 |
| Zinc / <i>Sink</i> | 380 |
| Lead / <i>Lood</i> | 130 |
| Ice / <i>Ys</i> | 2 100 |
| Brass | 380 |
| Mercury / <i>Kwik</i> | 140 |
| Methylated spirits / <i>Brandspiritus</i> | 2 400 |

TABLE 2: FORMULAE/TABEL 2: FORMULES

HEAT AND THERMODYNAMICS/HITTE EN TERMODINAMIKA

| | | |
|-----------|--------------------|----------------------------------|
| $C = c m$ | $Q = c m \Delta T$ | $\Delta Q = \Delta U + \Delta W$ |
|-----------|--------------------|----------------------------------|

WAVES, SOUND AND LIGHT/GOLWE, KLANK EN LIG

| | |
|-------------------|--|
| $f = \frac{1}{T}$ | $\Delta v = \frac{\Delta x}{\Delta t}$ |
| $T = \frac{1}{f}$ | $v = f \lambda$ |

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 |
|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|
| (I) | (II) | | | | KEY/ SLEUTEL | | Atoomgetal | | | | | (III) | (IV) | (V) | (VI) | (VII) | (VIII) |
| 1 1 H | 3 3 Li | 11 11 Na | 19 19 K | 27 27 Co | 35 35 Br | 43 43 Tc | 51 51 Nb | 59 59 Rh | 67 67 Ho | 75 75 Re | 83 83 Tl | 91 91 Pa | 99 99 Es | 107 107 Nh | 115 115 Nh | 123 123 Nh | 131 131 Nh |
| 2 2 He | 4 4 Be | 12 12 Mg | 20 20 Ca | 28 28 Ni | 36 36 Kr | 44 44 Ru | 52 52 Mo | 60 60 Nd | 68 68 Er | 76 76 Os | 84 84 Po | 92 92 U | 100 100 Fm | 108 108 No | 116 116 Lv | 124 124 Lv | 132 132 Lv |
| 3 3 Li | 4 4 Be | 13 13 Al | 21 21 Sc | 29 29 Cu | 37 37 Rb | 45 45 Rh | 53 53 I | 61 61 Pm | 69 69 Tm | 77 77 Ir | 85 85 At | 93 93 Np | 101 101 Md | 109 109 Mt | 117 117 Ts | 125 125 Ts | 133 133 Nh |
| 4 4 Be | 5 5 B | 14 14 Si | 22 22 Ti | 30 30 Zn | 38 38 Sr | 46 46 Pd | 54 54 Xe | 62 62 Sm | 70 70 Yb | 78 78 Pt | 86 86 Rn | 94 94 Pu | 102 102 No | 110 110 Ds | 118 118 Og | 126 126 Lv | 134 134 Lv |
| 5 5 B | 6 6 C | 15 15 P | 23 23 V | 31 31 Ga | 39 39 Y | 47 47 Ag | 55 55 Mn | 63 63 Eu | 71 71 Lu | 79 79 Au | 87 87 Fr | 95 95 Am | 103 103 Lr | 111 111 Nh | 119 119 Nh | 127 127 Nh | 135 135 Nh |
| 6 6 C | 7 7 N | 16 16 S | 24 24 Cr | 32 32 Ge | 40 40 Zr | 48 48 Cd | 56 56 Fe | 64 64 Gd | 72 72 Hf | 80 80 Hg | 88 88 Ra | 96 96 Cm | 104 104 Fl | 112 112 Fl | 120 120 Fl | 128 128 Fl | 136 136 Fl |
| 7 7 N | 8 8 O | 17 17 Cl | 25 25 Mn | 33 33 As | 41 41 Nb | 49 49 In | 57 57 La | 65 65 Tb | 73 73 Ta | 81 81 Tl | 89 89 Ac | 97 97 Bk | 105 105 Nh | 113 113 Nh | 121 121 Nh | 129 129 Nh | 137 137 Nh |
| 8 8 O | 9 9 F | 18 18 Ar | 26 26 Fe | 34 34 Se | 42 42 Mo | 50 50 Sn | 58 58 Ce | 66 66 Dy | 74 74 W | 82 82 Pb | 90 90 Th | 98 98 Cf | 106 106 Lv | 114 114 Lv | 122 122 Lv | 130 130 Lv | 138 138 Lv |
| 9 9 F | 10 10 Ne | 19 19 K | 27 27 Co | 35 35 Br | 43 43 Tc | 51 51 Nb | 59 59 Rh | 67 67 Ho | 75 75 Re | 83 83 Bi | 91 91 Pa | 99 99 Es | 107 107 Nh | 115 115 Nh | 123 123 Nh | 131 131 Nh | 139 139 Nh |
| 10 10 Ne | 11 11 Na | 20 20 Ca | 28 28 Ni | 36 36 Kr | 44 44 Ru | 52 52 Mo | 60 60 Nd | 68 68 Er | 76 76 Os | 84 84 Po | 92 92 U | 100 100 Fm | 108 108 No | 116 116 Lv | 124 124 Lv | 132 132 Lv | 140 140 Og |
| 11 11 Na | 12 12 Mg | 21 21 Sc | 29 29 Cu | 37 37 Rb | 45 45 Rh | 53 53 I | 61 61 Pm | 69 69 Tm | 77 77 Ir | 85 85 At | 93 93 Np | 101 101 Md | 109 109 Mt | 117 117 Ts | 125 125 Ts | 133 133 Nh | 141 141 Og |
| 12 12 Mg | 13 13 Al | 22 22 Ti | 30 30 Zn | 38 38 Sr | 46 46 Pd | 54 54 Xe | 62 62 Sm | 70 70 Yb | 78 78 Pt | 86 86 Rn | 94 94 Pu | 102 102 No | 110 110 Ds | 118 118 Og | 126 126 Lv | 134 134 Lv | 142 142 Og |
| 13 13 Al | 14 14 Si | 23 23 V | 31 31 Ga | 39 39 Y | 47 47 Ag | 55 55 Mn | 63 63 Eu | 71 71 Lu | 79 79 Au | 87 87 Fr | 95 95 Am | 103 103 Lr | 111 111 Nh | 119 119 Nh | 127 127 Nh | 135 135 Nh | 143 143 Nh |
| 14 14 Si | 15 15 P | 24 24 Cr | 32 32 Ge | 40 40 Zr | 48 48 Cd | 56 56 Fe | 64 64 Gd | 72 72 Hf | 80 80 Hg | 88 88 Ra | 96 96 Cm | 104 104 Fl | 112 112 Fl | 120 120 Fl | 128 128 Fl | 136 136 Fl | 144 144 Og |
| 15 15 P | 16 16 S | 25 25 Mn | 33 33 As | 41 41 Nb | 49 49 In | 57 57 La | 65 65 Tb | 73 73 Ta | 81 81 Tl | 89 89 Ac | 97 97 Bk | 105 105 Nh | 113 113 Nh | 121 121 Nh | 129 129 Nh | 137 137 Nh | 145 145 Nh |
| 16 16 S | 17 17 Cl | 26 26 Fe | 34 34 Se | 42 42 Mo | 50 50 Sn | 58 58 Ce | 66 66 Dy | 74 74 W | 82 82 Pb | 90 90 Th | 98 98 Cf | 106 106 Lv | 114 114 Lv | 122 122 Lv | 130 130 Lv | 138 138 Lv | 146 146 Og |
| 17 17 Cl | 18 18 Ar | 27 27 Co | 35 35 Br | 43 43 Tc | 51 51 Nb | 59 59 Rh | 67 67 Ho | 75 75 Re | 83 83 Bi | 91 91 Pa | 99 99 Es | 107 107 Nh | 115 115 Nh | 123 123 Nh | 131 131 Nh | 139 139 Nh | 147 147 Nh |
| 18 18 Ar | 19 19 K | 28 28 Ni | 36 36 Kr | 44 44 Ru | 52 52 Mo | 60 60 Nd | 68 68 Er | 76 76 Os | 84 84 Po | 92 92 U | 100 100 Fm | 108 108 No | 116 116 Lv | 124 124 Lv | 132 132 Lv | 140 140 Og | 148 148 Og |
| 19 19 K | 20 20 Ca | 29 29 Cu | 37 37 Rb | 45 45 Rh | 53 53 I | 61 61 Pm | 69 69 Tm | 77 77 Ir | 85 85 At | 93 93 Np | 101 101 Md | 109 109 Mt | 117 117 Ts | 125 125 Ts | 133 133 Nh | 141 141 Og | 149 149 Og |
| 20 20 Ca | 21 21 Sc | 30 30 Zn | 38 38 Sr | 46 46 Pd | 54 54 Xe | 62 62 Sm | 70 70 Yb | 78 78 Pt | 86 86 Rn | 94 94 Pu | 102 102 No | 110 110 Ds | 118 118 Og | 126 126 Lv | 134 134 Lv | 142 142 Og | 150 150 Og |
| 21 21 Sc | 22 22 Ti | 31 31 Ga | 39 39 Y | 47 47 Ag | 55 55 Mn | 63 63 Eu | 71 71 Lu | 79 79 Au | 87 87 Fr | 95 95 Am | 103 103 Lr | 111 111 Nh | 119 119 Nh | 127 127 Nh | 135 135 Nh | 143 143 Nh | 151 151 Nh |
| 22 22 Ti | 23 23 V | 32 32 Ge | 40 40 Zr | 48 48 Cd | 56 56 Fe | 64 64 Gd | 72 72 Hf | 80 80 Hg | 88 88 Ra | 96 96 Cm | 104 104 Fl | 112 112 Fl | 120 120 Fl | 128 128 Fl | 136 136 Fl | 144 144 Og | 152 152 Og |
| 23 23 V | 24 24 Cr | 33 33 As | 41 41 Nb | 49 49 In | 57 57 La | 65 65 Tb | 73 73 Ta | 81 81 Tl | 89 89 Ac | 97 97 Bk | 105 105 Nh | 113 113 Nh | 121 121 Nh | 129 129 Nh | 137 137 Nh | 145 145 Nh | 153 153 Nh |
| 24 24 Cr | 25 25 Mn | 34 34 Se | 42 42 Mo | 50 50 Sn | 58 58 Ce | 66 66 Dy | 74 74 W | 82 82 Pb | 90 90 Th | 98 98 Cf | 106 106 Lv | 114 114 Lv | 122 122 Lv | 130 130 Lv | 138 138 Lv | 146 146 Og | 154 154 Og |
| 25 25 Mn | 26 26 Fe | 35 35 Br | 43 43 Tc | 51 51 Nb | 59 59 Rh | 67 67 Ho | 75 75 Re | 83 83 Bi | 91 91 Pa | 99 99 Es | 107 107 Nh | 115 115 Nh | 123 123 Nh | 131 131 Nh | 139 139 Nh | 147 147 Nh | 155 155 Nh |
| 26 26 Fe | 27 27 Co | 36 36 Kr | 44 44 Ru | 52 52 Mo | 60 60 Nd | 68 68 Er | 76 76 Os | 84 84 Po | 92 92 U | 100 100 Fm | 108 108 No | 116 116 Lv | 124 124 Lv | 132 132 Lv | 140 140 Og | 148 148 Og | 156 156 Og |
| 27 27 Co | 28 28 Ni | 37 37 Rb | 45 45 Rh | 53 53 I | 61 61 Pm | 69 69 Tm | 77 77 Ir | 85 85 At | 93 93 Np | 101 101 Md | 109 109 Mt | 117 117 Ts | 125 125 Ts | 133 133 Nh | 141 141 Og | 149 149 Og | 157 157 Og |
| 28 28 Ni | 29 29 Cu | 38 38 Sr | 46 46 Pd | 54 54 Xe | 62 62 Sm | 70 70 Yb | 78 78 Pt | 86 86 Rn | 94 94 Pu | 102 102 No | 110 110 Ds | 118 118 Og | 126 126 Lv | 134 134 Lv | 142 142 Og | 150 150 Og | 158 158 Og |
| 29 29 Cu | 30 30 Zn | 39 39 Y | 47 47 Ag | 55 55 Mn | 63 63 Eu | 71 71 Lu | 79 79 Au | 87 87 Fr | 95 95 Am | 103 103 Lr | 111 111 Nh | 119 119 Nh | 127 127 Nh | 135 135 Nh | 143 143 Nh | 151 151 Nh | 159 159 Nh |
| 30 30 Zn | 31 31 Ga | 40 40 Zr | 48 48 Cd | 56 56 Fe | 64 64 Gd | 72 72 Hf | 80 80 Hg | 88 88 Ra | 96 96 Cm | 104 104 Fl | 112 112 Fl | 120 120 Fl | 128 128 Fl | 136 136 Fl | 144 144 Og | 152 152 Og | 160 160 Og |
| 31 31 Ga | 32 32 Ge | 41 41 Nb | 49 49 In | 57 57 La | 65 65 Tb | 73 73 Ta | 81 81 Tl | 89 89 Ac | 97 97 Bk | 105 105 Nh | 113 113 Nh | 121 121 Nh | 129 129 Nh | 137 137 Nh | 145 145 Nh | 153 153 Nh | 161 161 Nh |
| 32 32 Ge | 33 33 As | 42 42 Mo | 50 50 Sn | 58 58 Ce | 66 66 Dy | 74 74 W | 82 82 Pb | 90 90 Th | 98 98 Cf | 106 106 Lv | 114 114 Lv | 122 122 Lv | 130 130 Lv | 138 138 Lv | 146 146 Og | 154 154 Og | 162 162 Og |
| 33 33 As | 34 34 Se | 43 43 Tc | 51 51 Nb | 59 59 Rh | 67 67 Ho | 75 75 Re | 83 83 Bi | 91 91 Pa | 99 99 Es | 107 107 Nh | 115 115 Nh | 123 123 Nh | 131 131 Nh | 139 139 Nh | 147 147 Nh | 155 155 Nh | 163 163 Nh |
| 34 34 Se | 35 35 Br | 44 44 Ru | 52 52 Mo | 60 60 Nd | 68 68 Er | 76 76 Os | 84 84 Po | 92 92 U | 100 100 Fm | 108 108 No | 116 116 Lv | 124 124 Lv | 132 132 Lv | 140 140 Og | 148 148 Og | 156 156 Og | 164 164 Og |
| 35 35 Br | 36 36 Kr | 45 45 Rh | 53 53 I | 61 61 Pm | 69 69 Tm | 77 77 Ir | 85 85 At | 93 93 Np | 101 101 Md | 109 109 Mt | 117 117 Ts | 125 125 Ts | 133 133 Nh | 141 141 Og | 149 149 Og | 157 157 Og | 165 165 Og |
| 36 36 Kr | 37 37 Rb | 46 46 Pd | 54 54 Xe | 62 62 Sm | 70 70 Yb | 78 78 Pt | 86 86 Rn | 94 94 Pu | 102 102 No | 110 110 Ds | 118 118 Og | 126 126 Lv | 134 134 Lv | 142 142 Og | 150 150 Og | 158 158 Og | 166 166 Og |
| 37 37 Rb | 38 38 Sr | 47 47 Ag | 55 55 Mn | 63 63 Eu | 71 71 Lu | 79 79 Au | 87 87 Fr | 95 95 Am | 103 103 Lr | 111 111 Nh | 119 119 Nh | 127 127 Nh | 135 135 Nh | 143 143 Nh | 151 151 Nh | 159 159 Nh | 167 167 Nh |
| 38 38 Sr | 39 39 Y | 48 48 Cd | 56 56 Fe | 64 64 Gd | 72 72 Hf | 80 80 Hg | 88 88 Ra | 96 96 Cm | 104 104 Fl | 112 112 Fl | 120 120 Fl | 128 128 Fl | 136 136 Fl | 144 144 Og | 152 152 Og | 160 160 Og | 168 168 Og |
| 39 39 Y | 40 40 Zr | 49 49 In | 57 57 La | 65 65 Tb | 73 73 Ta | 81 81 Tl | 89 89 Ac | 97 97 Bk | 105 105 Nh | 113 113 Nh | 121 121 Nh | 129 129 Nh | 137 137 Nh | 145 145 Nh | 153 153 Nh | 161 161 Nh | 169 169 Nh |
| 40 40 Zr | 41 41 Nb | 50 50 Sn | 58 58 Ce | 66 66 Dy | 74 74 W | 82 82 Pb | 90 90 Th | 98 98 Cf | 106 106 Lv | 114 114 Lv | 122 122 Lv | 130 130 Lv | 138 138 Lv | 146 146 Og | 154 154 Og | 162 162 Og | 170 170 Og |
| 41 41 Nb | 42 42 Mo | 51 51 Sb | 59 59 Rh | 67 67 Ho | 75 75 Re | 83 83 Bi | 91 91 Pa | 99 99 Es | 107 107 Nh | 115 115 Nh | 123 123 Nh | 131 131 Nh | 139 139 Nh | 147 147 Nh | 155 155 Nh | 163 163 Nh | 171 171 Nh |
| 42 42 Mo | 43 43 Tc | 52 52 Te | 60 60 Nd | 68 68 Er | 76 76 Os | 84 84 Po | 92 92 U | 100 100 Fm | 108 108 No | 116 116 Lv | 124 124 Lv | 132 132 Lv | 140 140 Og | 148 148 Og | 156 156 Og | 164 164 Og | 172 172 Og |
| 43 43 Tc | 44 44 Ru | 53 53 I | 61 61 Pm | 69 69 Tm | 77 77 Ir | 85 85 At | 93 93 Np | 101 101 Md | 109 109 Mt | 117 117 Ts | 125 125 Ts | 133 133 Nh | 141 141 Og | 149 149 Og | 157 157 Og | 165 165 Og | 173 173 Og |
| 44 44 Ru | 45 45 Rh | 54 54 Xe | 62 62 Sm | 70 70 Yb | 78 78 Pt | 86 86 Rn | 94 94 Pu | 102 102 No | 110 110 Ds | 118 118 Og | 126 126 Lv | 13 | | | | | |

