Junior Chemistry Challenge
2026

Time allowed: 45 minutes

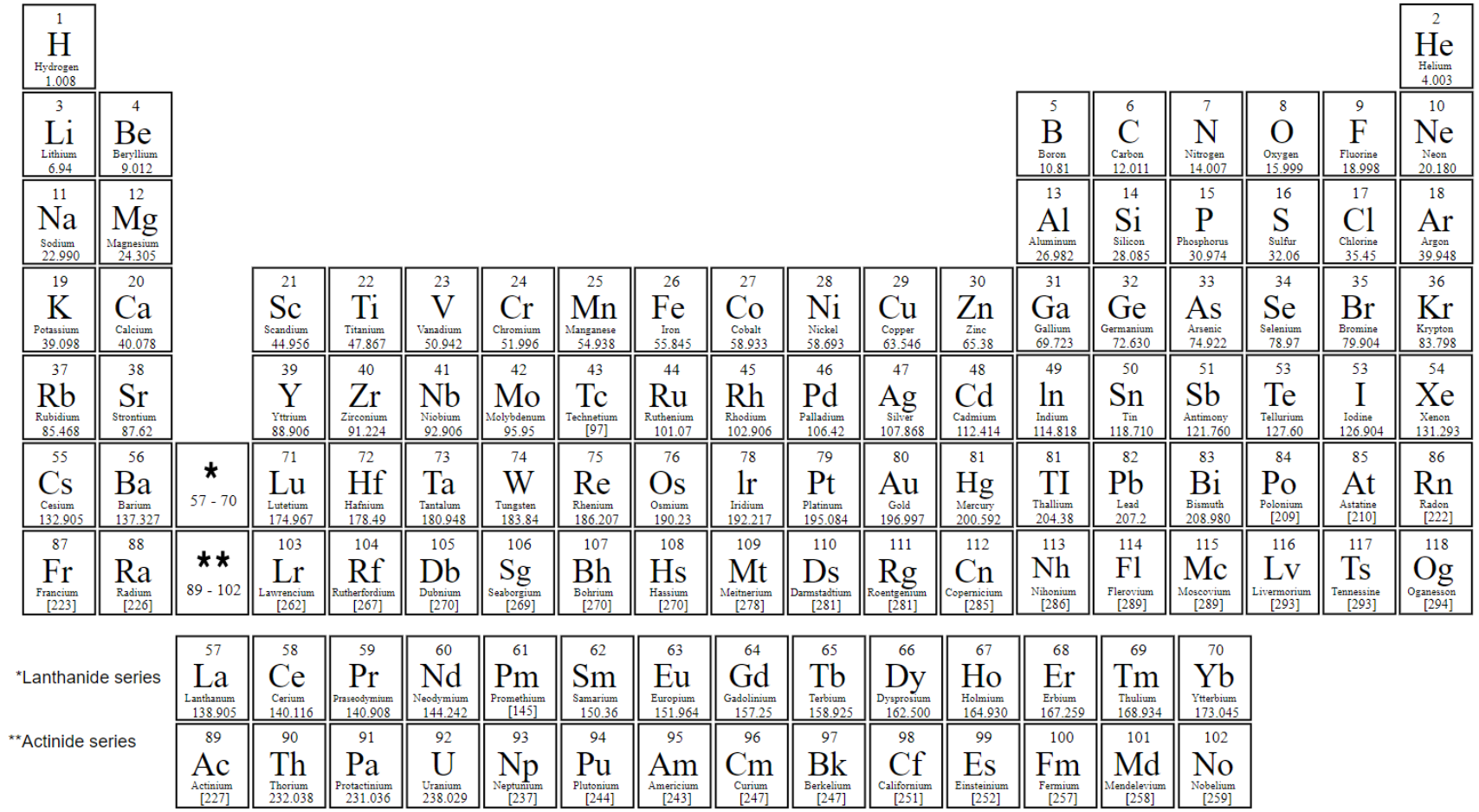
Instructions:

- Answer all the questions.
- The marks for each question are shown in brackets.
- Calculators are permitted.
- Do not start until you are instructed to do so.
- A Periodic Table is provided on the first page.

To administer the Junior Chemistry Challenge, your name, academic year, school, and score will be securely recorded in a database. After certificates and prizes are awarded, all entries will be anonymised. By taking part in the Junior Chemistry Challenge you consent to your data being handled in this manner.

Name: _____ Year: _____

Question:	1	2	3	Total
Max:	10	15	15	40
Mark:				


1 H Hydrogen 1.008
2 He Helium 4.003
3 Li Lithium 6.94
4 Be Beryllium 9.012
5 B Boron 10.81
6 C Carbon 12.011
7 N Nitrogen 14.007
8 O Oxygen 15.999
9 F Fluorine 18.998
10 Ne Neon 20.180
11 Na Sodium 22.990
12 Mg Magnesium 24.305
13 Al Aluminum 26.982
14 Si Silicon 28.085
15 P Phosphorus 30.974
16 S Sulfur 32.06
17 Cl Chlorine 35.45
18 Ar Argon 39.948
19 K Potassium 39.098
20 Ca Calcium 40.078
21 Sc Scandium 44.956
22 Ti Titanium 47.867
23 V Vanadium 50.942
24 Cr Chromium 51.996
25 Mn Manganese 54.938
26 Fe Iron 55.845
27 Co Cobalt 58.933
28 Ni Nickel 58.693
29 Cu Copper 63.546
30 Zn Zinc 65.38
31 Ga Gallium 69.723
32 Ge Germanium 72.630
33 As Arsenic 74.922
34 Se Selenium 78.97
35 Br Bromine 79.904
36 Kr Krypton 83.798
37 Rb Rubidium 85.468
38 Sr Strontium 87.62
39 Y Yttrium 88.906
40 Zr Zirconium 91.224
41 Nb Niobium 92.906
42 Mo Molybdenum 95.95
43 Tc Technetium [97]
44 Ru Ruthenium 101.07
45 Rh Rhodium 102.906
46 Pd Palladium 106.42
47 Ag Silver 107.868
48 Cd Cadmium 112.414
49 In Indium 114.818
50 Sn Tin 118.710
51 Sb Antimony 121.760
53 Te Tellurium 127.60
53 I Iodine 126.904
54 Xe Xenon 131.293
55 Cs Cesium 132.905
56 Ba Barium 137.327
* 57 - 70
71 Lu Lutetium 174.967
72 Hf Hafnium 178.49
73 Ta Tantalum 180.948
74 W Tungsten 183.84
75 Re Rhenium 186.207
76 Os Osmium 190.23
78 Ir Iridium 192.217
79 Pt Platinum 195.084
80 Au Gold 196.997
81 Hg Mercury 200.592
81 Tl Thallium 204.38
82 Pb Lead 207.2
83 Bi Bismuth 208.980
84 Po Polonium [209]
85 At Astatine [210]
86 Rn Radon [222]
87 Fr Francium [223]
88 Ra Radium [226]
** 89 - 102
103 Lr Lawrencium [262]
104 Rf Rutherfordium [267]
105 Db Dubnium [270]
106 Sg Seaborgium [269]
107 Bh Bohrium [270]
108 Hs Hassium [270]
109 Mt Meitnerium [278]
110 Ds Darmstadtium [281]
111 Rg Roentgenium [281]
112 Cn Copernicium [285]
113 Nh Nihonium [286]
114 Fl Flerovium [289]
115 Mc Moscovium [289]
116 Lv Livermorium [293]
117 Ts Tennessine [293]
118 Og Oganesson [294]
*Lanthanide series
57 La Lanthanum 138.905
58 Ce Cerium 140.116
59 Pr Praseodymium 140.908
60 Nd Neodymium 144.242
61 Pm Promethium [145]
62 Sm Samarium 150.36
63 Eu Europium 151.964
64 Gd Gadolinium 157.25
65 Tb Terbium 158.925
66 Dy Dysprosium 162.500
67 Ho Holmium 164.930
68 Er Erbium 167.259
69 Tm Thulium 168.934
70 Yb Ytterbium 173.045
**Actinide series
89 Ac Actinium [227]
90 Th Thorium 232.038
91 Pa Protactinium 231.036
92 U Uranium 238.029
93 Np Neptunium [237]
94 Pu Plutonium [244]
95 Am Americium [243]
96 Cm Curium [247]
97 Bk Berkelium [247]
98 Cf Californium [251]
99 Es Einsteinium [252]
100 Fm Fermium [257]
101 Md Mendelevium [258]
102 No Nobelium [259]

1. Please circle the correct answer. There is **only one** correct answer to each question.

   (a) X, Y, and Z are all different elements in the first three periods:

   - X and Y are in the same group of the Periodic Table.
   - Y and Z are in the same period of the Periodic Table.
   - Z has a larger atomic number than X.

   Which of the following statements is **false**? [1]

   A. X and Y can form ions with the same charge

   B. An atom of Z has more electrons than an atom of X

   C. X and Y will react to form an ionic compound

   D. Atoms of X and Z have different numbers of electron shells

   E. When Y and Z form ions they lose or gain electrons from the same shell

   (b) Which of the following reactions does not involve oxidation and reduction? [1]

   A. $CaCO_3 \longrightarrow CaO + CO_2$

   B. $CH_4 + 2\,O_2 \longrightarrow CO_2 + 2\,H_2O$

   C. $Cl_2 + 2\,KBr \longrightarrow 2\,KCl + Br_2$

   D. $CuSO_4 + Zn \longrightarrow ZnSO_4 + Cu$

   E. $2\,Na + 2\,H_2O \longrightarrow 2\,NaOH + H_2$

   (c) The solubility of a salt in water increases if the charge on the ions is $1+/1-$ and there is a large difference in the size of the ions. Based on this rule, which of the following salts is the most soluble in water? [1]

   A. BaO

   B. AlN

   C. LiF

   D. KI

   E. CsF

   (d) A sample of H_2 contains the isotopes ^1H and ^2H. The relative molecular mass of H_2 in the sample is 2.4. What percent of each isotope is in the sample? [1]

   A. ^1H: 90%, ^2H: 10%

   B. ^1H: 80%, ^2H: 20%

   C. ^1H: 75%, ^2H: 25%

   D. ^1H: 60%, ^2H: 40%

   E. ^1H: 50%, ^2H: 50%

(e) Element X has the following properties:

- X is stored in oil.
- The salts of X are white.
- X cannot displace sodium from its salts.

What is element X? [1]

A. K

B. Mg

C. Cu

D. Li

E. Cl

(f) Below are two consecutive elements from the Periodic Table in Groups 6 and 7 respectively.

52	53
Te	**I**
tellurium	iodine
127.6	126.9

Which of the following statements about these elements is **false**? [1]

A. Every atom of iodine has more protons than every atom of tellurium

B. Tellurium forms anions with a more negative charge than iodine

C. All atoms of tellurium and iodine have more neutrons than protons

D. The average iodine atom has more neutrons than the average tellurium atom

E. They form compounds with hydrogen with the formulae H_2Te and HI

(g) Pure $NiSO_4$ can be made by the following reaction:

$$NiO\,(s) + H_2SO_4\,(aq) \longrightarrow NiSO_4\,(aq) + H_2O\,(l)$$

When this reaction is carried out, excess NiO is added to H_2SO_4 but excess H_2SO_4 is never added to NiO.

What is the best explanation for this? [1]

A. To reduce the vigour of the reaction

B. Excess NiO is easier to remove than excess H_2SO_4

C. H_2SO_4 is more dangerous than NiO

D. To ensure the reaction has the highest possible rate

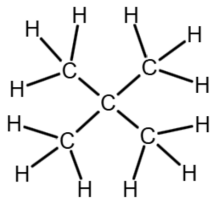
E. To ensure the reaction goes to completion

(h) Catalytic reforming is used to turn long-chain alkanes into more useful substances. A reaction for the reformation of decane is given below.

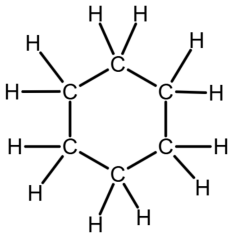
$$C_{10}H_{22} \longrightarrow \mathbf{X} + 2\,C_2H_4 + 2\,H_2$$

What is a possible structure of **X**?

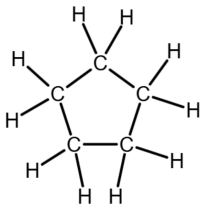
A.



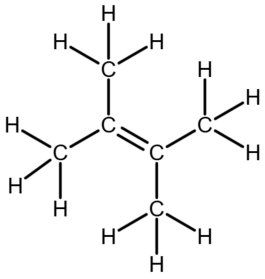
B.



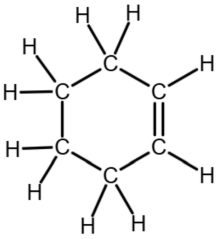
C.



D.



E.



(i) Four molecules of ammonium perchlorate decompose to give four molecules of hydrogen chloride, two molecules of nitrogen, five molecules of oxygen, and six molecules of water. What is the formula of ammonium perchlorate? [1]

A. NH_4ClO_4

B. NH_2ClO_2

C. $N_2H_4ClO_5$

D. NH_4ClO_3

E. $N_4H_{16}Cl_4O_{16}$

(j) KNO_3 is a very soluble salt, with a solubility of 316 g/100mL. 15.8 g of KNO_3 is dissolved in a volume of water. The water has to be reduced to 20% of its original volume to just form a saturated solution. What was the original volume of water? [1]

A. 1 mL

B. 4 mL

C. 5 mL

D. 20 mL

E. 25 mL

Total for Question 1: 10

2. Swimming pools need to be disinfected to stop bacteria growing. The compounds used to disinfect swimming pools are hydrogen hypochlorite, ClOH, or the hypochlorite anion, ClO^-.

(a) Draw a dot-and-cross diagram for ClOH showing outer electrons only. [2]

One way to disinfect water is to dissolve chlorine in it.

(b) Chlorine is produced by reacting sodium chloride with water by passing an electric current through it. The products of this reaction are chlorine gas, hydrogen gas, and a soluble salt which increases the pH of the solution. Write a balanced equation for this reaction. [2]

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Chlorine and water react and disinfect the water by producing hydrogen hypochlorite:

$$Cl_2\,(aq) + H_2O\,(l) \longrightarrow HCl\,(aq) + ClOH\,(aq)$$

(c) The solution produced by this reaction is unsafe for swimmers to use. Suggest why this is and how this might be solved. [2]

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A safer way to disinfect swimming pools is to dissolve $Ca(ClO)_2$ in the water.

(d) i. What is the percent by mass of the hypochlorite anion, ClO^-, in $Ca(ClO)_2$? [3]
[You may find the following A_r values helpful: Ca = 40, Cl = 35.5, O = 16]

ii. It is recommended that a swimming pool be disinfected with 2 parts per million (ppm) by mass of ClO^-. An Olympic-sized swimming pool is 50 m long, is 2 m deep, and has 10 lanes each 2.5 m wide. What mass of $Ca(ClO)_2$ is needed to disinfect an Olympic-sized pool?
The density of water is $1000\,kg\,m^{-3}$.
[ppm is like percent but smaller: 1 ppm means 1 part in 1,000,000, compared with 1% meaning 1 part in 100] [3]

(e) The distinctive 'swimming pool smell' is chloramine, formed when urea from swimmers' urine and sweat reacts with hydrogen hypochlorite in the water.

$$CO(NH_2)_2 + 2\,ClOH \longrightarrow 2\,X + H_2CO_3$$

What is the formula of chloramine, labelled X in the above reaction? [1]

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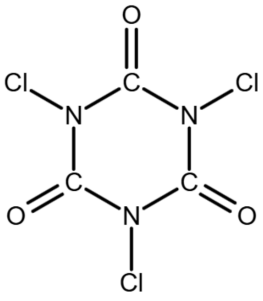
Pools can also be disinfected with a compound called Trichlor.

(f) The displayed formula of Trichlor is given below. It reacts with three molecules of water to produce three molecules of hydrogen hypochlorite and one molecule of cyanuric acid. Draw the displayed formula of cyanuric acid. [2]



Total for Question 2: 15

3. Chemists often want to know how much energy is released or absorbed by a chemical reaction. This energy change is given the symbol ΔH.

(a) One way chemists can do this is by using average bond energies. Average bond energies are the mean energies required to break a particular type of bond, averaged over many different compounds.

To work out the energy change of a chemical reaction using average bond energies, calculate the total energy of the bonds broken in the reactants and subtract the total energy of the bonds formed in the products.

i. The equation for the combustion of methane is:

$$CH_4 + 2\,O_2 \longrightarrow CO_2 + 2\,H_2O$$

Draw the displayed formulae of all the reactants and products in this reaction showing all the bonds. If a reactant or product appears more than once in the balanced equation, draw the correct number of separate molecules. [2]

ii. Using these values of average bond energies calculate the energy change for the combustion of methane. You may not need to use all the values. [3]

Bond	C−H	C−O	C=O	O−O	O=O	O−H
Energy / kJ	412	358	742	144	498	464

iii. The actual value for the combustion of methane is −890 kJ. Suggest a reason why this is different from the value calculated above. [1]

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The energy of formation ($\Delta_f H$) of a substance is the energy change when one molecule of that substance is made from its elements. For example, the equation which represents $\Delta_f H$ for NaCl is: $Na + \frac{1}{2} Cl_2 \longrightarrow NaCl$

(b) Give the equation which represents $\Delta_f H$ for the following substances:

i. H_2O [1]

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ii. NH_3 [1]

.....

iii. C_2H_5OH [1]

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(c) Explain why the energy of formation for an element is always 0 kJ. [1]

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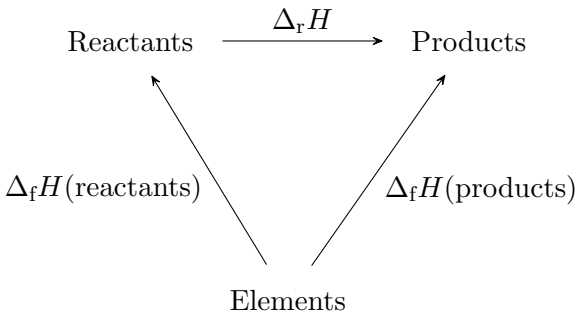
Energy changes in chemical reactions have a special property. It doesn't matter which reaction pathway you take from the reactants to the products the energy change will always be the same. This is called Hess' Law.

This means we can draw a cycle of reactions with the reactants going to the products via their elements. This is called a Hess Cycle:



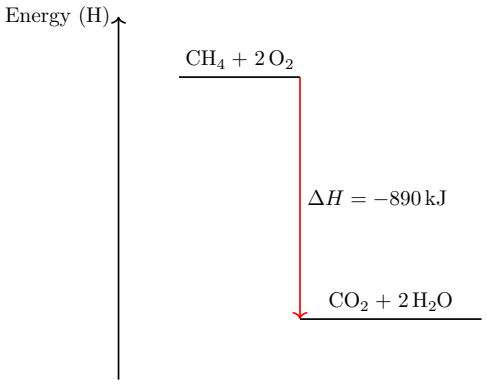
Because of Hess' Law, the energy change of the reaction ($\Delta_r H$) can be expressed as:

$$\Delta_r H = -\Delta_f H(\text{reactants}) + \Delta_f H(\text{products})$$

(d) The thermal decomposition of $CaCO_3$ produces calcium oxide and carbon dioxide. However the energy change of this reaction cannot be measured directly. It can be calculated from a Hess Cycle with the formation energies. Draw a Hess Cycle for this reaction and calculate the energy change of the thermal decomposition of $CaCO_3$. [3]

$\Delta_f H(CaCO_3) = -1207\,kJ \quad \Delta_f H(CaO) = -635\,kJ \quad \Delta_f H(CO_2) = -394\,kJ$

Energy changes can be shown using an energy level diagram. For the combustion of methane in part (a), the energy change is $-890\,kJ$, so the products are at a lower energy than the reactants and to show this an arrow points downwards from the reactants to the products.



(e) Draw an energy level diagram for your Hess Cycle in part (d). You should clearly show the substances at each energy level and an arrow indicating whether the formation energies and reaction energy is going up or down. [2]

Total for Question 3: 15

End of Paper

Junior Chemistry Challenge is kindly supported by The Perse School, Cambridge.

Structures in Questions 1(h) and 2(f) drawn in Marvin JS
(https://marvinjs-demo.chemaxon.com/latest/demo.html)
Typeset in LaTeX