SOUTH AFRICAN AGENCY FOR SCIENCE AND TECHNOLOGY ADVANCEMENT

60th PHYSICS OLYMPIAD
GRADE 10 - 11
2025
INSTRUCTIONS

Please read the instructions carefully before answering the questions

This is a multiple-choice paper. Please answer all the questions on the answer sheet provided. Each question is followed by answers marked A, B, C, and D. **Only one answer is correct**. Choose the correct answer and shade the corresponding circle on the answer sheet completely, using an **HB pencil**.

NB! The answer sheets are marked electronically – do not make any other dots or marks on the answer sheet. Select only one answer for each question or your answer will be discarded**. Ensure that you shade your selection clearly.**

Note that the question numbers 1 to 100 on the answer sheet moves from top to bottom in several columns. Ensure that the number of your selection on the answer sheet corresponds with the number of the question in your examination paper. Should you make a mistake, please erase the incorrect answer completely

The use of **non-programmable** electronic calculators is permitted.

To avoid disqualification - You are required to complete **all** the information requested on the answer sheet. Please complete the information in script, as well as shade the corresponding blocks. *If the corresponding blocks are not shaded appropriately, your results will be returned without a name, and you will be disqualified*. Do not fold the answer sheets.

This paper consists of 24 pages and 5 data sheets.

Three hours are allowed to answer the questions

1. A car is travelling at a speed of 30 $m \cdot s^{-1}$ on a straight road.

   What would be the speed of the car in $km \cdot h^{-1}$?

   A. 8,33 $km \cdot h^{-1}$
   B. 30 $km \cdot h^{-1}$
   C. 108 $km \cdot h^{-1}$
   D. 130 $km \cdot h^{-1}$

2. Two cyclists are cycling in opposite directions along the sideline of a rectangular field. It is observed that they covered the same distance over a time interval of 3 s.

   Which one of the following physical quantities could be the SAME regarding the cyclists over the interval of 3 s?

   A. Momentum
   B. Average speed
   C. Average velocity
   D. Displacement

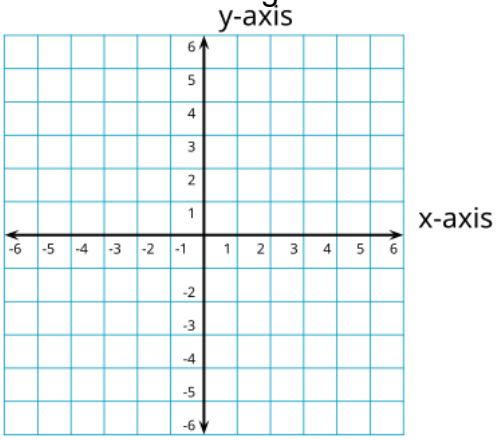
3. A person inside a train walks toward the front of the train at 5 $km \cdot h^{-1}$. The train is moving at 80 $km \cdot h^{-1}$ with respect to the ground.

   What is the walking person's speed, relative to the ground?

   A. 5 $km \cdot h^{-1}$
   B. 75 $km \cdot h^{-1}$
   C. 80 $km \cdot h^{-1}$
   D. 85 $km \cdot h^{-1}$

4. **In which one of the following cases does a car have a negative velocity and a positive acceleration?**

   A car that is traveling in the …



   A. negative x-direction at a constant speed
   B. negative x-direction with an increasing speed
   C. negative x-direction with a decreasing speed
   D. positive x-direction with an increasing speed

5. You drive 4 km at 30 $km \cdot h^{-1}$ and then another 4 km at 50 $km \cdot h^{-1}$.

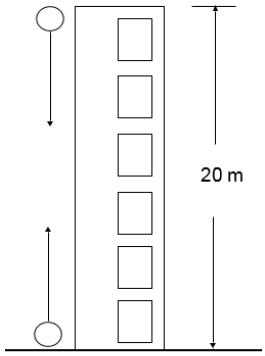
   What is your average speed for the whole 8-km trip?

   A. More than 40 $km \cdot h^{-1}$
   B. Equal to 40 $km \cdot h^{-1}$
   C. Less than 40 $km \cdot h^{-1}$
   D. There is not enough information to find the answer.

6. A ball **A** is dropped from the top of a tall building. At the same instant, a second bal, **B** is thrown upward from the ground level. A moment later when ball **B** reaches its maximum height, ball **A** passes ball **B**.

   Which one of the following physical quantities are NOT equal at the instant when ball **A** passes ball **B**?

Ball **A**



Ball **B**

   A. The magnitude of accelerations of the two balls.
   B. The magnitude of velocities of the two balls.
   C. The magnitude of displacements of the two balls.
   D. The time taken by each ball to pass the other.

7. A force of 1 000 N is exerted at a bearing of 120°.

   The southerly component of this force is … N.

   A. 0
   B. 500
   C. 866
   D. 1 000

8. Two cars, **X** and **Y**, have the same magnitude of momentum.

Car **X**

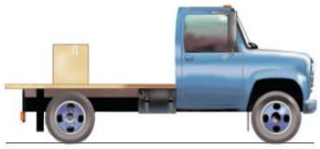
Car **Y**

Car **Y** can have more kinetic energy than car **X** only if car **Y** …

A. has higher speed than car X.
B. has lower speed than car X.
C. has the same speed as car X.
D. None of the above.

9. A truck is travelling horizontally to the right at constant speed. When the truck suddenly slows down, the crate on the ROUGH truck bed starts to slide forward.

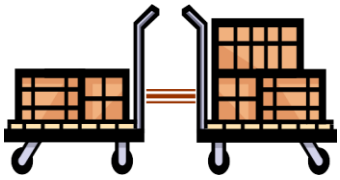
In what direction could the net force be on the crate?



A. No direction. The net force is zero.
B. Straight down (because of gravity).
C. Horizontal and to the right.
D. Horizontal and to the left.

10. Two trolleys, A and B, are held together. Trolley B has a bigger mass than trolley A. The two trolleys are forced apart by releasing a compressed spring.

The magnitude of the … is the same for both trolleys.

A  **B**

A. force
B. speed
C. acceleration
D. change in velocity

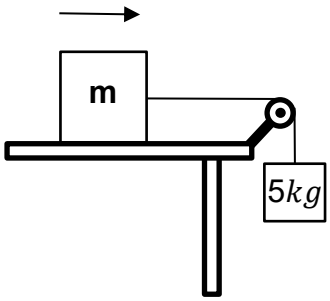
11. The figure alongside shows a book on a table.

According to Newton's third law, the reaction force of the weight of the book is the … .

A. gravitational force exerted by the earth on the book
B. force exerted by the book on the table
C. force exerted by the table on the book
D. gravitational force exerted by the book on the earth

12. A block of mass **m** on a frictionless surface is attached to a hanging 5 kg mass as shown in the diagram alongside. The system accelerates at 2,6 $m \cdot s^{-2}$.

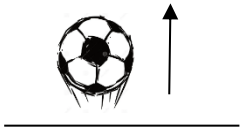
The mass of block **m** is _____ kg.



A. 1,3
B. 13,9
C. 19
D. 24

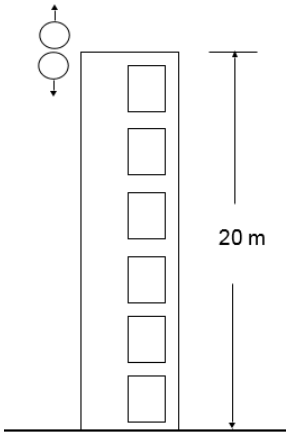
13. A 0,6kg ball is projected directly upward with an initial speed of 15 $m \cdot s^{-1}$. The ball experiences an average air resistance force of 2,4 N.

What is the maximum height reached by the ball?



A. 8,2 m
B. 11 m
C. 16 m
D. 19 m

14. Ball **A** is thrown vertically upwards with a speed of v from the top of a tall building. At the same instant, a second identical ball **B** is thrown vertically downward with the same speed v from the top of the same tall building. Ignore the effect of air friction.



Which one of the following statements is true for the time before one of the balls hits the ground?

A. The kinetic energies of the two balls are equal

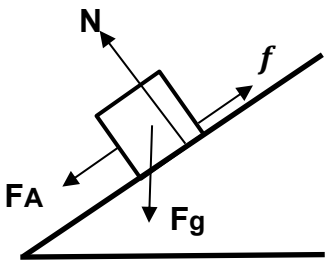
B. The kinetic energy of ball **A** is greater than the kinetic energy of ball **B**.

C. The mechanical energies of the two balls are equal

D. The mechanical energy of ball **A** is greater than the mechanical energy of ball **B**.

15. If you push a heavy crate down a ramp at a constant velocity, only four forces will act on the crate as shown alongside.

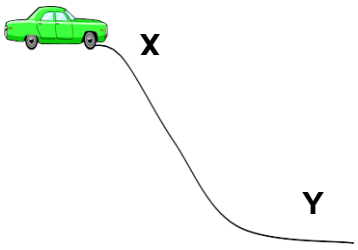
Which force will do the greatest magnitude of work on the crate?



A. Applied force
B. Normal force
C. Gravitational force
D. Frictional force

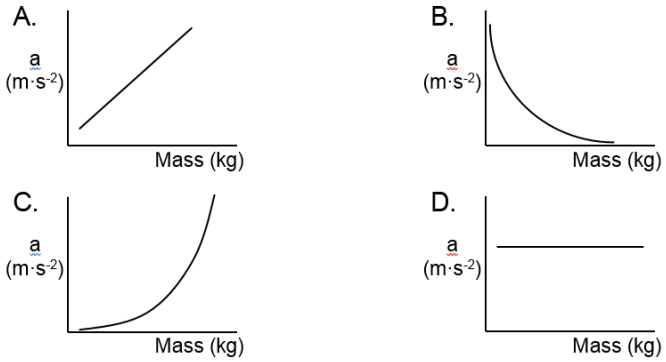
16. Two toy cars, one with a mass of **M**, and the other with a mass of 2**M**, start from rest at **X**. They are allowed to run down a FRICTIONLESS track to **Y**.

How will the velocities of the cars compare when they have reached point Y?



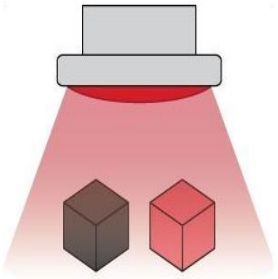
A. Both cars will have the same velocity.
B. The car of mass 2**M** will have the greater velocity.
C. The car of mass **M** will have the greater velocity.
D. Both will have a velocity of zero.

17. **Which graph best represents the relationship between acceleration due to gravity and mass for objects near the surface of Earth?** [Ignore the effect of air resistance.]



18. Red light of frequency f and wavelength λ shines on two objects. The red light is then replaced by a blue light.

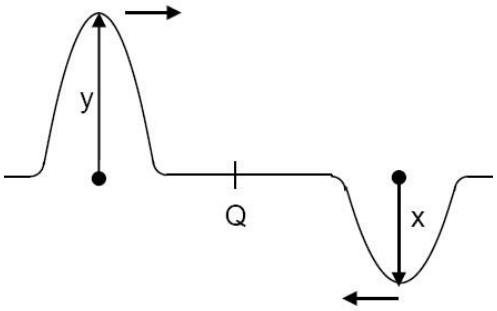
How do the frequency and the wavelength of blue light shining on the objects now compare with that of red light?



A. Frequency greater than f and wavelength equal to λ
B. Frequency less than f and wavelength greater than λ
C. Frequency greater than f and wavelength less than λ
D. Frequency equal to f and wavelength less than λ

19. Two pulses are travelling towards each other along a string, as shown in the diagram alongside.

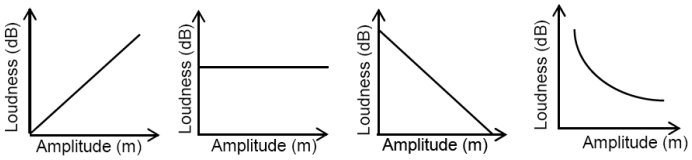
When the centres of the two pulses meet at Q, the amplitude of the resultant pulse will be …



A. x + y
B. 2(x + y)
C. y – x
D. 2(y – x)

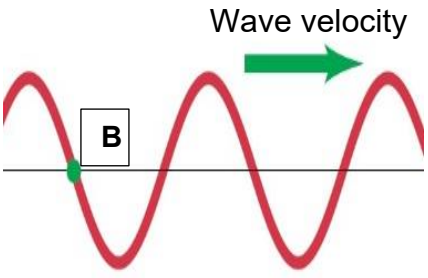
20. **Which one of the graphs below best describes the relationship between loudness and the amplitude of a wave?**

A B C D



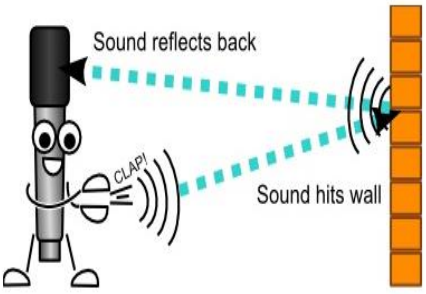
21. Consider a wave in a string moving to the right, as shown below.

What is the direction of the velocity of a particle of string at point **B**?



A. Vertically upwards
B. Vertically downwards
C. Horizontally to the right
D. The particle is stationary

22. **Do you expect an echo to return to you more quickly on a hot day or a cold day?**



A. Cold day
B. Hot day
C. Same on both days
D. You do not get an echo on a cold day

23. If you go down a mine tunnel that is 100 meters below the surface of the earth, your weight …

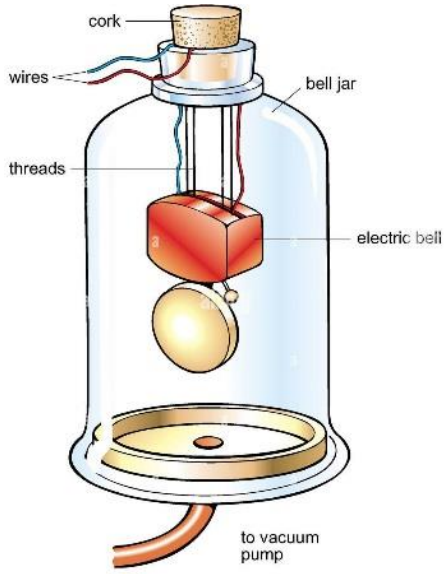
A. remains the same as your weight on the surface.
B. becomes slightly more than your weight on the surface.
C. becomes slightly less than your weight on the surface.
D. becomes zero.

24. Which prefix is often used with scientific terms to indicate that something is the same, equal or constant?

A. mega
B. meta
C. iso
D. quasi

25. Thabang does an experiment with a ringing bell in a sealed glass chamber. He then removes the air from the chamber with a vacuum pump.

Why can the bell be seen vibrating but not heard?



A. Light can travel through a vacuum, but sound cannot.
B. Sound waves have greater amplitude than light waves.
C. Sound waves have higher frequency than light waves.
D. Light waves travel slower than sound waves.

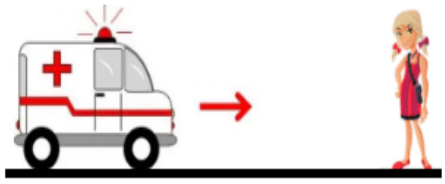
26. An ultrasonic wave is sent from a ship towards the bottom of the sea. It is found that the time interval between sending and receiving of the wave is 1,6 s. The velocity of sound in seawater is 1400 $m \cdot s^{-1}$.

What is the depth of the sea, in m, at this point?

A. 1 400
B. 1 120
C. 560
D. 2 240

27. A sound source approaches a stationary observer at constant velocity, passes the observer and moves away at the same constant velocity.

Which one of the following describes how the observed frequency changes as the sound source move towards and away from the stationary observer?



A. The frequency gradually increases as the sound source approaches the observer, is maximum when the source is passing the observer and gradually decreases as the source moves away.

B. The constant lower frequency is observed when the sound source is approaching and a constant higher frequency is observed when the source is moving away.

C. The constant higher frequency is observed when the sound source is approaching and a constant lower frequency is observed when the source is moving away.

D. The frequency does not change whether the sound source is approaching or moving away.

28. A fighter jet is flying at subsonic speed (below the speed of sound) and then accelerates to supersonic speed (faster than sound). **What happens to the sound waves and air pressure around the jet as it crosses the speed of sound (Mach 1)?**

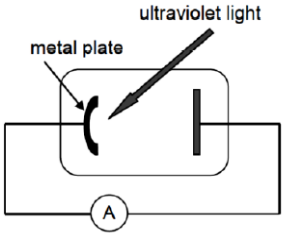
A. The sound waves spread out evenly in all directions, and air pressure decreases smoothly.

B. The sound waves bunch up into a single shock wave, creating a loud "sonic boom" due to sudden pressure changes.

C. The sound waves disappear completely because the jet is now moving faster than sound.

D. The air pressure remains constant, and no special effects occur when breaking the sound barrier.

29. Which one of the following provides evidence that light behaves as particles?



A. Light can be diffracted.

B. Light is refracted by a triangular prism.

C. Light ejects electrons from a metal surface.

D. The speed of light decreases when it travels from air to glass.

30. Which one of the following metals will NOT be attracted to a magnet?

A. Iron
B. Cobalt
C. Copper
D. Nickel

31. Consider efficiencies of hydro-turbines and generators.

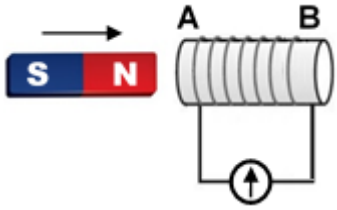
What is the overall efficiency of the unit if the efficiency of a hydro-turbine is 80% and the efficiency of a generator is 90%?

A. 85%
B. 72%
C. 90%
D. 80%

32. Which one of the following is NOT an application of permanent magnets?

A. Speakers
B. Telephones
C. Compasses
D. Remote control units

33. In the diagram below, the north pole of a bar magnet approaches end **A** of a solenoid.

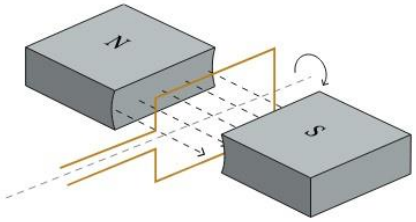


Which one of the following statements about the polarity of **A** and **the direction of the magnetic field INSIDE the solenoid is CORRECT as the NORTH POLE** approaches **A**?

	Polarity of A	**Direction of field in solenoid**
A	South pole	A to B
B	North pole	B to A
C	North pole	A to B
D	South pole	B to A

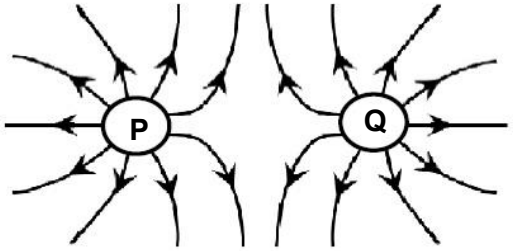
34. A rectangular coil is placed inside a magnetic field and rotated clockwise to induce an emf.

Which one of the following changes will increase the induced emf?



A. Rotating the coil slower.
B. Decreasing the number of turns of the coil.
C. Increasing the speed of rotation of the coil.
D. Changing the polarity of the magnets.

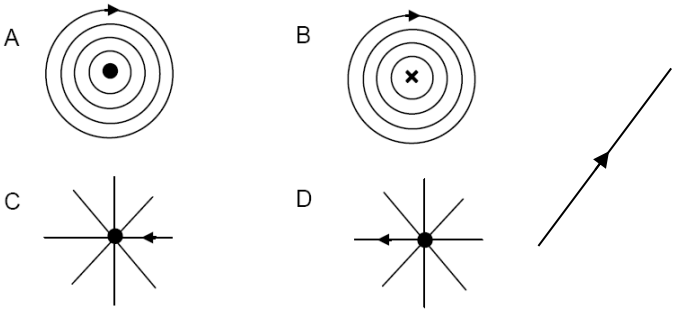
35. P and Q are two bodies which are charged electrostatically. The electric field pattern between them is shown in the diagram alongside.



From this field pattern we know that …

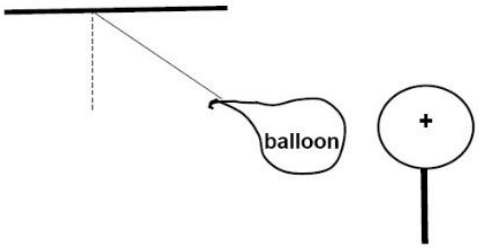
A. P and Q are both positive.
B. P and Q are both negative.
C. P is negative and Q is positive.
D. P is positive and Q is negative.

36. Which one of the sketches below represents the CORRECT magnetic field pattern around a straight current-carrying conductor?



37. A balloon is brought closer to a positively charged sphere as shown in the diagram alongside. The balloon is attracted to the sphere.

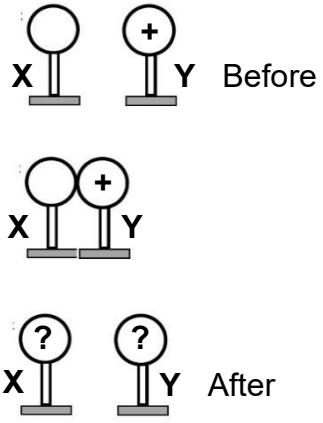
Which one of the following is the type of charge on the balloon?



A. Positive
B. Positive or neutral
C. Negative or neutral
D. Negative or positive

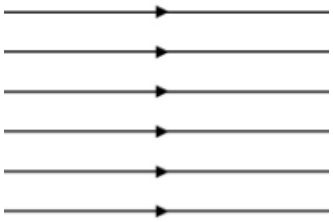
38. A positively charged metal sphere **Y** on an insulated stand is brought into contact with an identical neutral metal sphere **X** on an insulated stand. The two spheres are then separated.

Which one of the following describes the charge on each sphere after they have been separated?



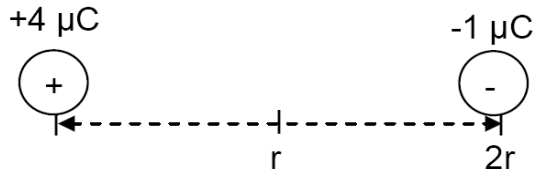
A. Sphere **X** is positive and sphere **Y** is neutral.
B. Both spheres are positive.
C. Sphere **X** is neutral and sphere **Y** is positive.
D. Both spheres are neutral.

39. The electric field at a point is defined as …



A. the region in space where an electric charge experiences an electrostatic force.
B. the electrostatic force per unit positive charge.
C. directly proportional to the product of the charges.
D. the direction that a negative test charge would move.

40. A negative charge of 1 μC, which is free to move, is placed at a distance $2\boldsymbol{r}$ from a positive charge of 4 μC.

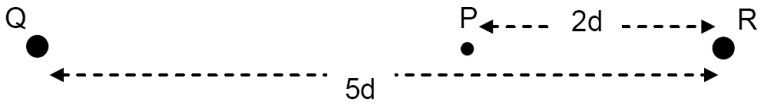


Which one of the following statements regarding the -1 μC charge, when it is at distance r, is CORRECT?

The electrostatic force experienced by the -1 μC charge will …

A. remain the same.
B. be halved.
C. be doubled.
D. increase four times.

41. A negative charge **Q** is placed at a distance of **5d** from another charge **R**.



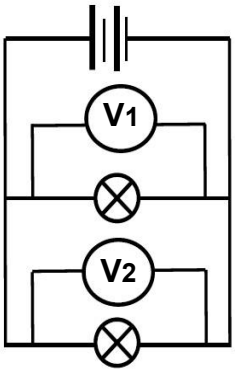
Which one of the following combinations concerning the ratio of the charges **Q** and **R** and the charge on **R**, is CORRECT **if the net electric field at point P, at a distance of 2d from R, is ZERO ?**

	Ratio of the Charges	Charge on R
A	4:9	Positive
B	3:2	Negative
C	5:2	Positive
D	9:4	Negative

42. Two identical light bulbs are connected in parallel, as shown in the circuit diagram below. Voltmeters **V1** and **V2** are connected across each light bulb.

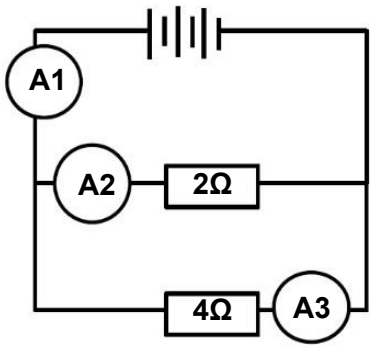
Which one of the following voltmeter readings is CORRECT?

A. V1 = V2
B. V1 = 2V2
C. V1 = ½V2
D. V1 = ¼V2



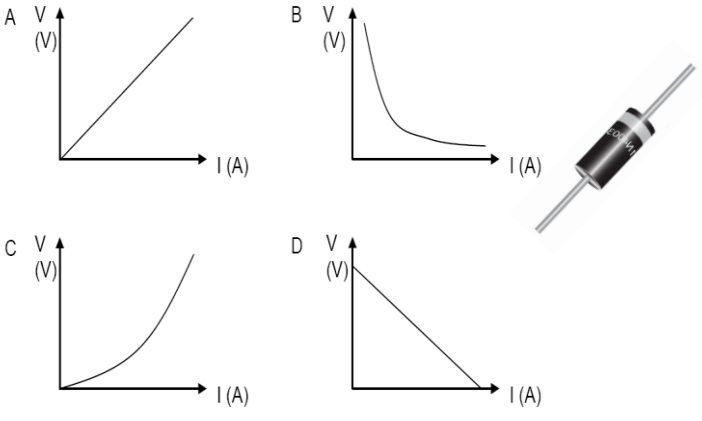
43. Consider the circuit diagram below.

How will the readings on ammeters **A1**, **A2** and **A3** compare with each other?

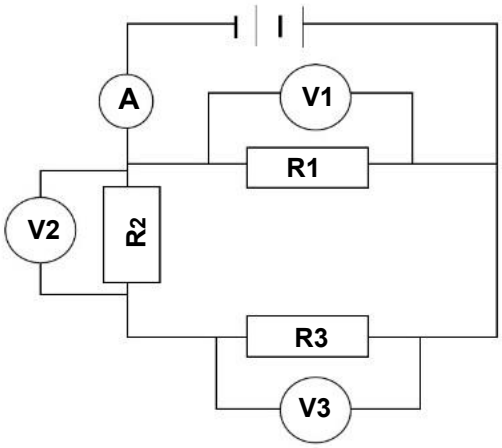


A. A1 = A2 = A3
B. A1 = A2 + A3
C. (A2 + A3) > A1
D. A2 < A3 < A1

44. Which one of the graphs below CORRECTLY represents the relationship between potential difference and current in a non-ohmic resistor?



45. In the circuit diagram below, the battery has negligible internal resistance. The resistance of the ammeter and wires may also be ignored.



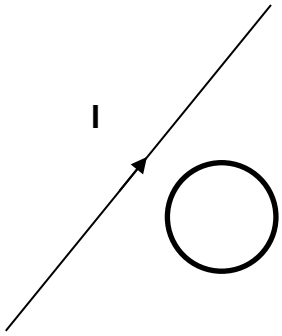
The reading on voltmeter V3 will be equal to …

A. V1
B. ½ V1
C. V1 + V2
D. V1 - V2

46. Which one of the following will NOT increase a generator's voltage output?

A. Increasing the number of turns in the coil.
B. Increasing the area of the coil.
C. Increasing the magnetic field through the coil.
D. Increasing fuel in the generator tank.

47. A long straight wire carries a direct current **I** as shown below. A small loop of wire rests in the plane of the page.



Which one of the following will not induce a current in the loop?

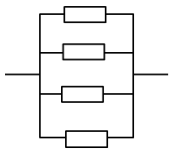
A. Increasing the current in the straight wire.

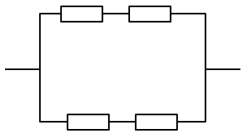
B. Moving the loop in a direction parallel to the wire.

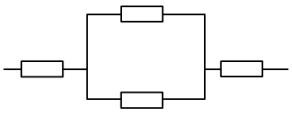
C. Rotating the loop.

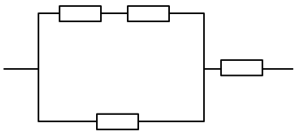
D. Moving the loop away from the wire without rotating it.

48. Which arrangement of four identical resistors will have the highest equivalent resistance?

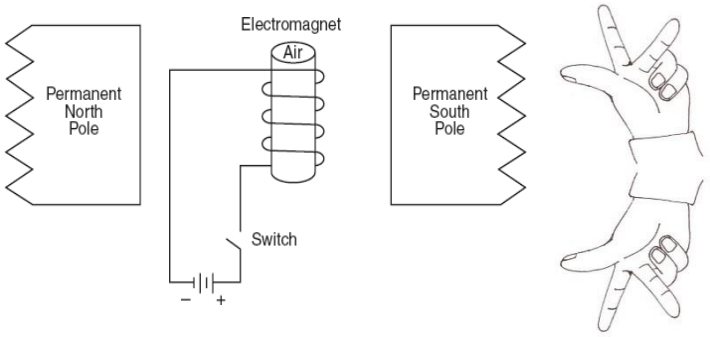
A. 

B. 

C. 

D. 

49. An electromagnet with an air core is located within the magnetic field between two permanent magnets.



At the instant the switch is closed, and a current begins to flow through the coil of the electromagnet, the coil will experience …

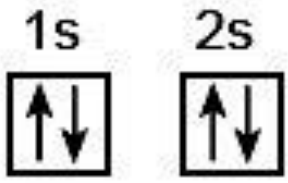
A. a force directed out of the page
B. a counterclockwise torque
C. no electromagnetic force
D. a clockwise torque

50. Which one of the following statements about transformers is false?

A. Transformers work using AC or DC.
B. If the current in the secondary is higher, the voltage is lower.
C. If the voltage in the secondary is higher, the current is lower.
D. If no flux is lost, the product of the voltage and the current is the same in the primary and secondary coils.

51. The orbital notation of an atom in the ground state is shown alongside.

Which atom is represented by this notation?

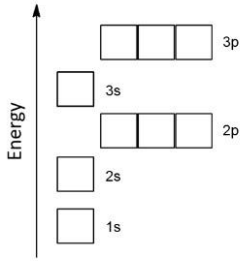


A. C
B. N
C. B
D. Be

52. Which one of the following compounds is an example of a binary compound?

A. He
B. H2O
C. H2
D. H_2SO_4

53. Which electron configuration represents an atom in the excited state?



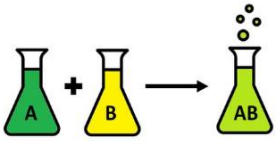
A. $1s^2 2s^2 2p^5 3s^1$
B. $1s^2 2s^2 2p^6 3s^1$
C. $1s^2 2s^2 2p^6 3s^2$
D. $1s^2 2s^2 2p^6 3s^2 3p^1$

54. Given the reaction:

Cℓ(g) + Cℓ(g) → Cℓ2(g) + energy

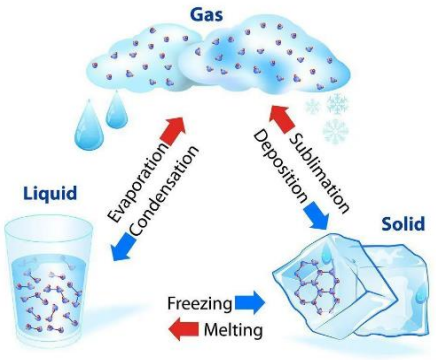
Which statement best describes the reaction?

A bond is …



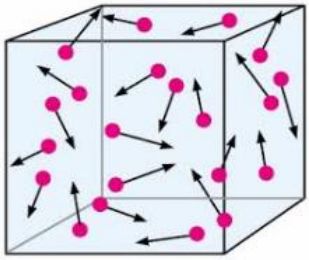
A. formed and energy is absorbed.
B. formed and energy is released.
C. broken and energy is absorbed.
D. broken and energy is released.

55. Which one of the following statements is INCORRECT about the properties of a physical change?



A. During a physical change, the compounds may rearrange themselves, but the bonds between the atoms will not break.
B. A physical change in matter is mostly reversible.
C. Energy is absorbed when matter changes from a solid to a liquid.
D. Atoms are conserved, but molecules are not conserved during a physical change.

56. **According to the kinetic theory of matter for a solid, the particles …**



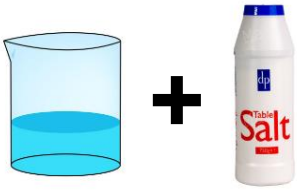
A vibrate about their fixed positions and the solid has a fixed shape.

B are free to move and the solid is compressible.

C are free to move and the solid has a fixed shape.

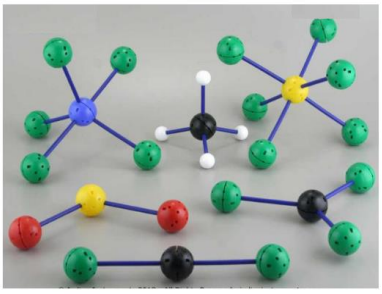
D vibrate about their fixed positions and the solid is compressible.

57. **The primary intermolecular forces in aqueous sodium chloride solution, NaCℓ(aq) are …** .



A. ionic bonds
B. induced dipole forces
C. dipole-dipole forces
D. ion-dipole forces

58. **Which of the following species has a shape based on two lone pairs and two bond pairs?**



A. NH3
B. CO2
C. H_2O
D. HCℓ

59. One mole of any gas occupies the same volume at the same temperature and pressure.

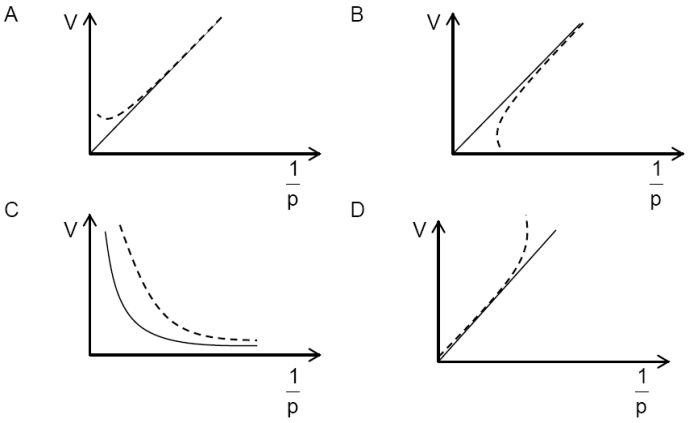
This statement is known as …

A. Charles's law.
B. Gay-Lussac's law.
C. Boyle's law.
D. Avogadro's law.

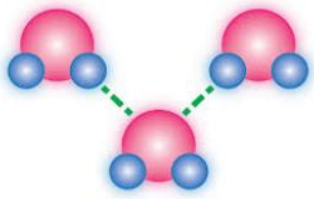
THE GAS LAWS

60. Which one of the graphs below CORRECTLY represents the deviation of a real gas from ideal gas behaviour at very high pressures?

The dotted line represents the graph of the real gas.

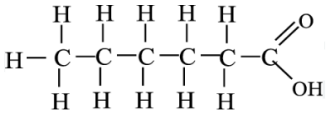


61. Which one of the following combinations correctly indicates the STRONGEST intermolecular forces found in water and ammonia respectively?



	Water	Ammonia
A	Hydrogen bonds	Hydrogen bonds
B	Dipole-dipole forces	London forces
C	Hydrogen bonds	London forces
D	Hydrogen bonds	Dipole-dipole forces

62. The EMPIRICAL FORMULA of C6H12O2 is …



A. $C_3H_6O_2$
B. $C_6H_6O_2$
C. $C_6H_{12}O_2$
D. C_3H_6O

63. How many distinct chain isomers do pentane have?

A. 1
B. 2
C. 3
D. 4

64. Which potassium salt is 28.9% chlorine by mass?

A. KCℓ
B. KCℓO
C. $KC\ell O_2$
D. $KC\ell O_3$

65. Which one of the following is the strongest natural fiber?

A. Cotton
B. Silk
C. Jute
D. Nylon

66. Elements **A**, **B** and **C** occur as Döbereiner's Triads. If the atomic mass of **A** is 40 $g.mol^{-1}$ and that of **C** is 137 $g.mol^{-1}$, what will be the atomic mass of **B** in $g.mol^{-1}$?

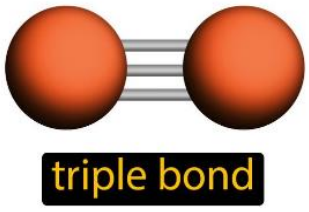
Li	Ca	Cl
Na	Sr	Br
K	Ba	I

Döbereiner's Triads

A. 35
B. 120
C. 88
D. 74

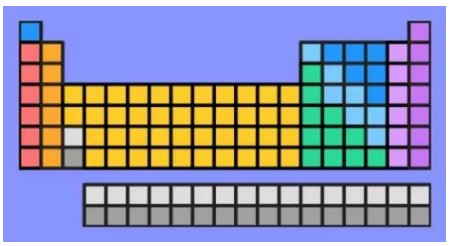
67. Which one of the following compounds has a triple bond?

A. NH3
B. SO3
C. O2
D. HCN



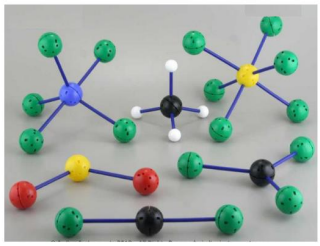
68. Which one of the following does not correspond to a group of elements on the periodic table?

A. Alkali
B. Alloys
C. Halogens
D. Group IV



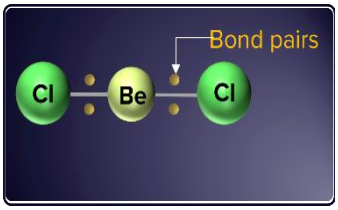
69. The shape of the molecule in which the central atom is surrounded by one lone pair and three bonding pairs is …

A. trigonal bipyramidal.
B. trigonal planar.
C. pyramidal.
D. tetrahedral.



70. The tendency of an atom to attract the bonding pair of electrons is known as …

A. electron affinity.
B. ionisation energy.
C. electronegativity.
D. polarity.



71. 4 moles of nitrogen gas are sealed in a balloon at a certain temperature, **T** and pressure, **p**. The volume of the balloon increases by 100% while the temperature remains constant.

The new pressure in the balloon is …

A. 0.5**p**
B. 0.75**p**
C. 1.5**p**
D. 2**p**

72. What is the energy called needed to break one mole of a compound's molecules into separate atoms?

A. Ionisation energy.
B. Bond energy.
C. Activation energy.
D. Lattice energy.

73. The molar masses of ethane, methanol and fluoromethane are comparable.

Which one of the following lists these compounds in order of increasing boiling point?

A. $C_2H_6 < CH_3OH < CH_3F$
B. $CH_3F < CH_3OH < C_2H_6$
C. $CH_3F < C_2H_6 < CH_3OH$
D. $C_2H_6 < CH_3F < CH_3OH$

74. Which one of the following species contains 21 neutrons and 19 electrons?

A. $^{41}_{20}Ca^{2+}$
B. $^{41}_{20}Ca^{+}$
C. $^{40}_{19}K^{+}$
D. $^{40}_{21}Sc^{2+}$

75. Which one of the following elements is a solid at room temperature?

A. F_2
B. $C\ell_2$
C. Br_2
D. I_2

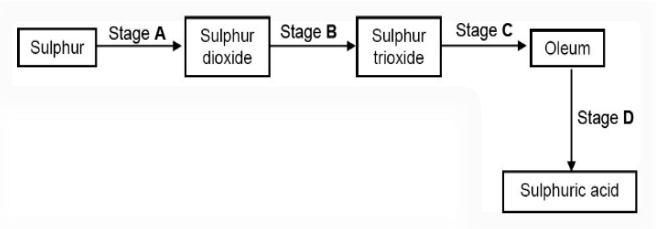
76. During the processing of gold ore, zinc is added to the gold cyanide solution to produce gold according to the balanced equation below:

$Zn(s) + 2NaAu(CN)2(aq) \rightarrow 2Au(s) + Zn(CN)2(aq) + 2NaCN(aq)$

The reducing agent in this reaction is …

A. Na^+
B. Au^+
C. Zn
D. CN^-

77. The flow diagram below shows four stages (**A**, **B**, **C** and **D**) in the conversion of sulphur to sulphuric acid.



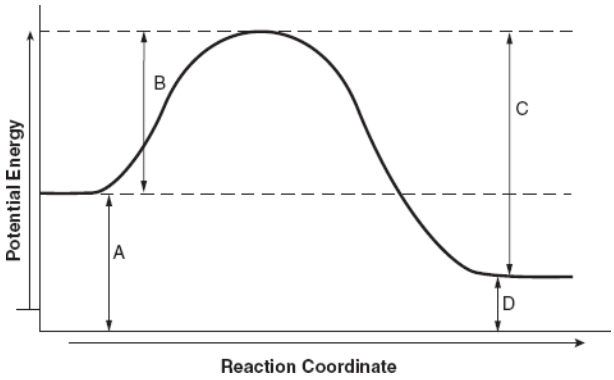
During Stage **B**, sulphur dioxide is changed to sulphur trioxide in the presence of a platinum catalyst.

What is the type of reaction occurring during this stage?

A. Hydrolysis
B. Oxidation
C. Sulphurisation
D. Substitution

78. A potential energy diagram is shown below.

Which letters represent the activation energy of the forward and reverse reactions, respectively?



A. A and C
B. A and D
C. B and C
D. B and D

79. Which of the following are amphiprotic in aqueous solutions?

I. H_3BO_3

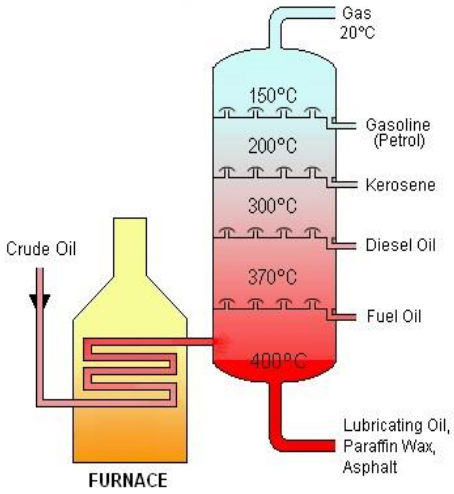
II. $H_2BO_3^-$

III. HBO_3^{2-}

IV. BO_3^{3-}

A. **I** only
B. **IV** only
C. **I** and **II** only
D. **II** and **III** only

80. Cracking hydrocarbon molecules will result in ….



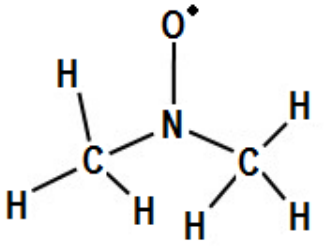
A. larger molecules with lower boiling points
B. larger molecules with higher boiling points
C. smaller molecules with lower boiling points
D. smaller molecules with higher boiling points

81. Which statement best describes a chemical reaction in which energy is released?

It is ….

A. exothermic and has a negative ΔH
B. exothermic and has a positive ΔH
C. endothermic and has a negative ΔH
D. endothermic and has a positive ΔH

82. The number of atoms present in a one gram sample of the dimethyl aminoxyl radicals, $(CH_3)_2NO$ is ….



A. 1.0×10^{22}
B. 6.0×10^{22}
C. 1.0×10^{23}
D. 6.0×10^{23}

83. Which of one of these processes is always exothermic?

A. Boiling
B. Melting
C. Freezing
D. Evaporation

84. Which process represents a chemical change?

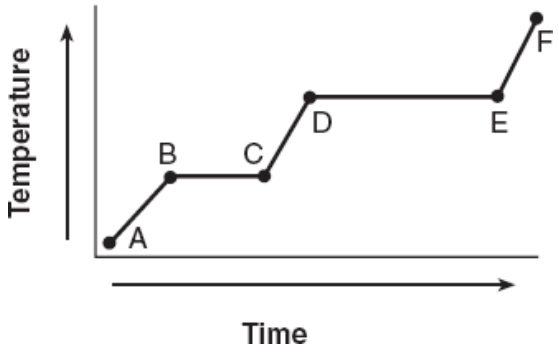
A. Melting of ice
B. Corrosion of copper
C. Evaporation of water
D. Crystallisation of sugar

85. A student can deduce the … of a chemical reaction from a potential energy diagram.

A. oxidation states of the reactants and products
B. average kinetic energy of the reactants and products
C. change in solubility of the reacting substances
D. energy released or absorbed during the reaction

86. The graph below represents the uniform heating of a substance, starting below its melting point, when the substance is solid.

Which line segments represent an increase in average kinetic energy of the particles?

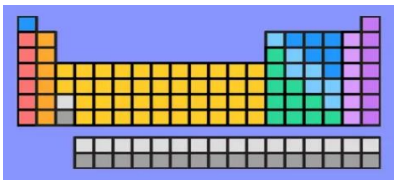


A. **AB** and **CD**
B. **DE** and **EF**
C. **AB** and **BC**
D. **BC** and **DE**

87. Given the reactions:

$2\mathbf{X}(s) + 2H_2O(\ell) \rightarrow 2\mathbf{X}^+(aq) + 2OH^-(aq) + H_2(g)$

$2\mathbf{Y}(s) + 2H_2O(\ell) \rightarrow 2\mathbf{Y}^+(aq) + 2OH^-(aq) + H_2(g)$



The unknowns, **X** and **Y**, are most likely...

A. metallic elements in the same group
B. metallic elements in the same period
C. non-metallic elements in the same group
D. non-metallic elements in the same period

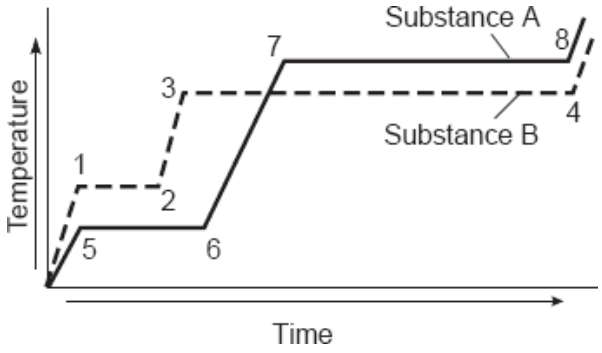
88. After being ignited in a Bunsen burner flame, a piece of magnesium ribbon burns brightly, giving off heat and light.

In this situation, the Bunsen burner flame provides ...

A. Heat of reaction
B. Ionisation energy
C. Activation energy
D. Heat of vaporisation

89. The graph shows heat being added at a constant rate to substance **A** and to substance **B**. Initially both substances are at temperatures below their melting points.

During which interval is the greatest amount of energy absorbed?



A. 1 – 2
B. 2 – 3
C. 3 – 4
D. 7 – 8

90. In a 20 g sample of molecules, which sample below has the greatest number of moles?

A. NH_3
B. N_2
C. CO_2
D. H_2

91. The chemical name for $Fe_2(SO_4)_3$ is … .

A. iron sulphite
B. iron(III) sulphate
C. iron(II) sulphate
D. iron sulphide

92. Prussian blue is a deep blue pigment containing Fe^{2+}, Fe^{3+} and CN^- ions. It has the formula $Fe_7(CN)_{18}$.

How many Fe^{2+} and Fe^{3+} ions are there per formula unit?

A. 0 Fe^{2+} and 6 Fe^{3+} ions
B. 3 Fe^{2+} and 4 Fe^{3+} ions
C. 4 Fe^{2+} and 3 Fe^{3+} ions
D. 5 Fe^{2+} and 2 Fe^{3+} ions

93. In which one of the following reactions is HCℓ oxidised?

A. $HC\ell(aq) + H2O(\ell) \rightarrow H3O^+(aq) + C\ell^-(aq)$
B. $CaCO3(s) + 2HC\ell(aq) \rightarrow CaC\ell2(aq) + H2O(\ell) + CO2(g)$
C. $NH3(aq) + HC\ell(aq) \rightarrow NH4C\ell(aq)$
D. $MnO2(aq) + 4HC\ell(aq) \rightarrow MnC\ell2(aq) + H2O(\ell) + C\ell2(g)$

94. The oxidation number of phosphorus in H3PO4 is ….

A. +3
B. -2
C. +2
D. +5

95. Which one of the following balanced equations represents a dissociation process?

A. $HC\ell(aq) \rightarrow H^+(aq) + C\ell^-(aq)$
B. $NaC\ell(s) \rightarrow Na^+(aq) + C\ell^-(aq)$
C. $Zn(s) + 2HC\ell(aq) \rightarrow ZnC\ell2(aq) + H2(g)$
D. $NaC\ell(aq) + AgNO3(aq) \rightarrow NaNO3(aq) + AgC\ell(s)$

96. Iron can be produced by reducing iron(III) oxide with carbon monoxide, as described by the following balanced chemical equation:

$$Fe_2O_{3(s)} + 3CO_{(g)} \rightarrow 2Fe_{(s)} + 3CO_{2(g)}$$

What mass of carbon dioxide is produced by the complete reduction of 16.0 grams of iron(III) oxide?

A. 4.4 g
B. 6.6 g
C. 8.8 g
D. 13.2 g

97. 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 H2SO4 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 CH3COOH solution.

98. Which one of the following balanced equations represents a redox reaction?

A. $H^+(aq) + OH^-(aq) \rightarrow H2O(\ell)$

B. $Mg(s) + CuSO4(aq) \rightarrow Cu(s) + MgSO4(aq)$

C. $2NaC\ell(aq) + Pb(NO3)2(aq) \rightarrow 2NaNO3(aq) + PbC\ell2(s)$

D. $H2SO4(aq) + Ba(NO3)2(aq) \rightarrow BaSO4(s) + 2HNO3(aq)$

99. A galvanic cell is constructed under standard conditions using cobalt in cobalt(II) nitrate solution and indium in indium(III) nitrate solution.

Half - reaction	E^{θ}, V
$Co^{2+}_{(aq)} + 2e^- \rightarrow Co_{(s)}$	-0.28
$In^{3+}_{(aq)} + 3e^- \rightarrow In_{(s)}$	-0.34

Which statements about this cell are correct?

I. The standard cell potential is -0.06 V.

II. Indium is the anode.

A. **I** only

B. **II** only

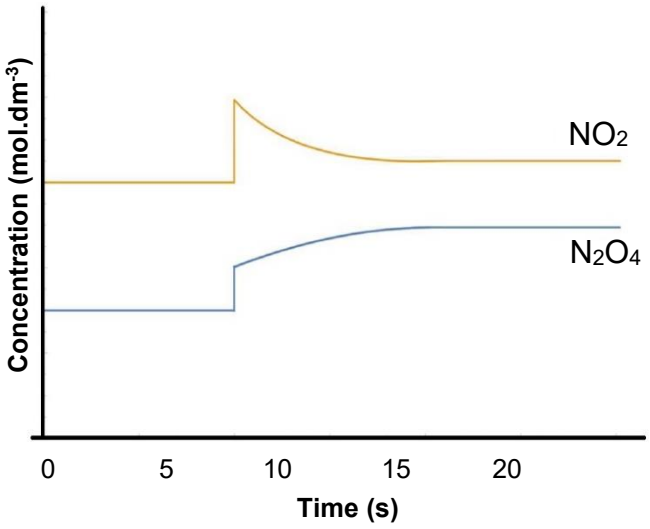
C. Both **I** and **II**

D. Neither **I** nor **II**

100. Nitrogen dioxide (NO2) dimerises to form N2O4, as represented by the equilibrium reaction:

$$2NO_{2(g)} \rightleftharpoons N_2O_{4(g)} \qquad \Delta H < 0$$

The following graph depicts the concentration of NO_2 and N_2O_4 gases in a closed reaction vessel.



At *t* = 10*s*, the equilibrium between the two species is disrupted, and a new equilibrium is reached at *t* = 20*s*.

Which one of the following disruptions at *t* = 10*s* would be consistent with the graph?

A. Addition of only N2O4 to the reaction vessel
B. Addition of only NO2 to the reaction vessel
C. Decrease in volume of the reaction vessel
D. Increase in temperature inside reaction vessel

TABLE 2: FORMULAE

MOTION

$v_f = v_i + a\Delta t$	$\Delta x = v_i\Delta t + \frac{1}{2}a\Delta t^2$ or $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$
$v_f^{\,2} = v_i^{\,2} + 2a\Delta x$ or $v_f^{\,2} = v_i^{\,2} + 2a\Delta y$	$\Delta x = \left(\frac{v_i + v_f}{2}\right)\Delta t$ or $\Delta y = \left(\frac{v_i + v_f}{2}\right)\Delta t$

WORK, ENERGY AND POWER

$W = F\Delta x\cos\theta$	$U = mgh$ or $E_P = mgh$
$K = \frac{1}{2}mv^2$ or $E_k = \frac{1}{2}mv^2$	$W_{net} = \Delta K$ or $W_{net} = \Delta E_k$ $\Delta K = K_f - K_i$ or $\Delta E_k = E_{kf} - E_{ki}$
$W_{nc} = \Delta K + \Delta U$ or $W_{nc} = \Delta E_k + \Delta E_p$	$P = \frac{W}{\Delta t}$
$P_{ave} = Fv_{ave}$	

FORCE

$F_{net} = ma$	$p = mv$
$f_s^{\,max} = \mu_s N$	$f_k = \mu_k N$
$F_{net}\Delta t = \Delta p$ $\Delta p = mv_f - mv_i$	$w = mg$
$F = G\frac{m_1m_2}{d^2}$ or $F = G\frac{m_1m_2}{r^2}$	$g = G\frac{M}{d^2}$ or $g = G\frac{M}{r^2}$

WAVES, SOUND AND LIGHT

$v = f\lambda$	$T = \frac{1}{f}$
$f_L = \frac{v \pm v_L}{v \pm v_s}f_s$ or $f_L = \frac{v \pm v_L}{v \pm v_b}f_b$	$E = hf$ or $E = \frac{hc}{\lambda}$
$E = W_0 + E_{k(max)}$ or $E = W_0 + K_{max}$ where $E = hf$ and $W_0 = hf_0$ and $E_{k(max)} = \frac{1}{2}mv_{max}^2$ or $K_{max} = \frac{1}{2}mv_{max}^2$	

ELECTRIC CIRCUITS

$R = \frac{V}{I}$	emf (ε) = I(R + r) emk (ε) = I(R + r)
$R_s = R_1 + R_2 + \ldots$ $\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots$	$q = I\Delta t$
$W = Vq$ $W = VI\Delta t$ $W = I^2R\Delta t$ $W = \frac{V^2\Delta t}{R}$	$P = \frac{W}{\Delta t}$ $P = VI$ $P = I^2R$ $P = \frac{V^2}{R}$

ALTERNATING CURRENT

$I_{rms} = \frac{I_{max}}{\sqrt{2}}$ $V_{rms} = \frac{V_{max}}{\sqrt{2}}$	$P_{ave} = V_{rms}I_{rms}$ $P_{ave} = I_{rms}^2R$ $P_{ave} = \frac{V_{rms}^2}{R}$

ELECTROSTATICS

$F = \frac{kQ_1Q_2}{r^2}$	$E = \frac{kQ}{r^2}$
$V = \frac{W}{q}$	$E = \frac{F}{q}$
$n = \frac{Q}{e}$ or $n = \frac{Q}{q_e}$	

TABLE 1: PHYSICAL CONSTANTS

NAME	SYMBOL	VALUE
Standard pressure	p^θ	$1{,}013 \times 10^5$ Pa
Molar gas volume at STP	V_m	22,4 $dm^3 \cdot mol^{-1}$
Standard temperature	T^θ	273 K
Charge on electron	e	$-1{,}6 \times 10^{-19}$ C
Avogadro's constant	N_A	$6{,}02 \times 10^{23}$ mol^{-1}

TABLE 2: FORMULAE

$n = \frac{m}{M}$	$n = \frac{N}{N_A}$
$c = \frac{n}{V}$ or $c = \frac{m}{MV}$	$n = \frac{V}{V_m}$
$\frac{c_a v_a}{c_b v_b} = \frac{n_a}{n_b}$	$pH = -\log[H_3O^+]$
$K_w = [H_3O^+][OH^-] = 1 \times 10^{-14}$ at 298 K	
$E^\theta_{cell} = E^\theta_{cathode} - E^\theta_{anode}$ or $E^\theta_{cell} = E^\theta_{reduction} - E^\theta_{oxidation}$ or $E^\theta_{cell} = E^\theta_{oxidisingagent} - E^\theta_{reducingagent}$	

TABLE 3: THE PERIODIC TABLE OF ELEMENTS

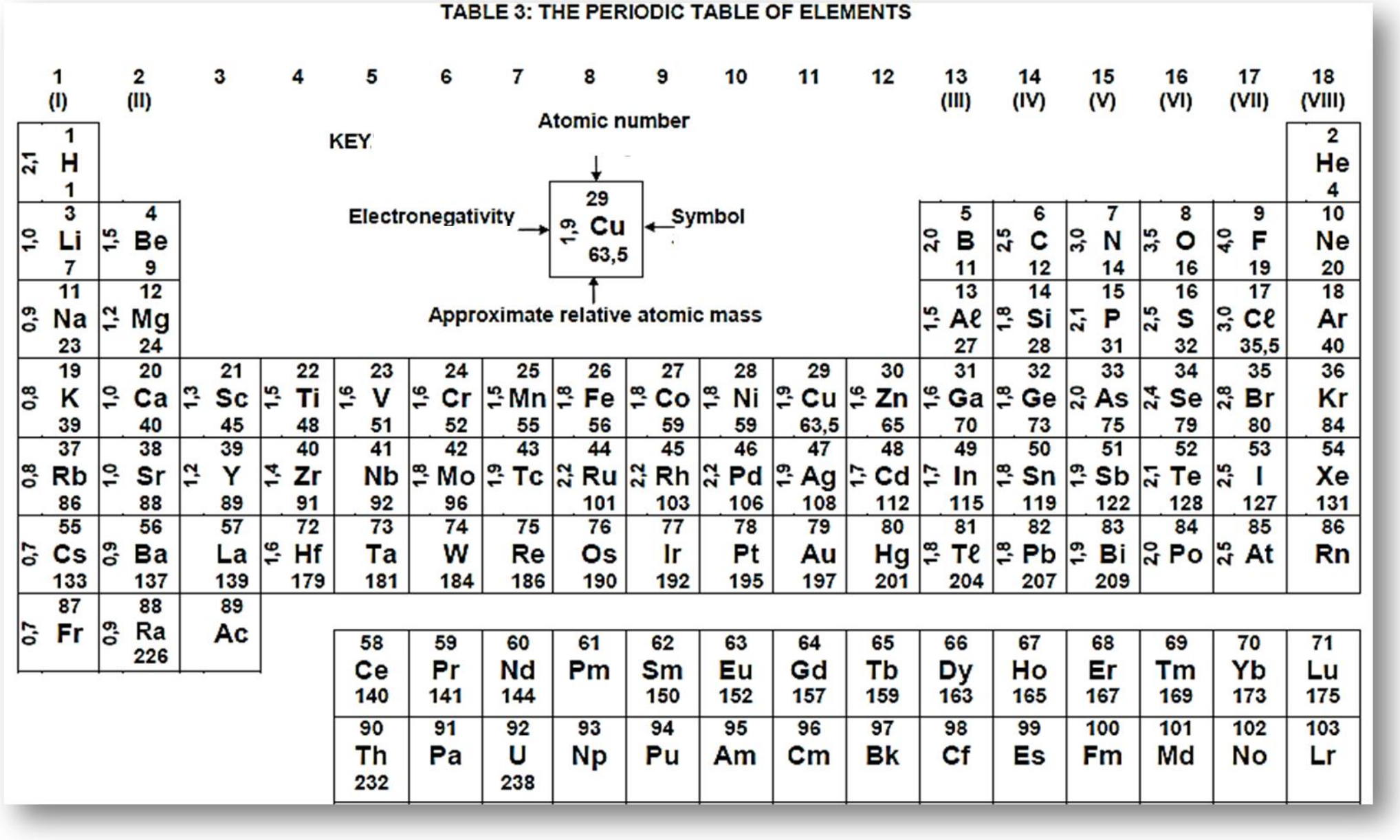


TABLE 4A: STANDARD REDUCTION POTENTIALS

Half-reactions/*Halfreactions*	E^θ (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

Increasing oxidising ability ↑

Increasing reducing ability ↓

TABLE 4B: STANDARD REDUCTION POTENTIALS

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

Increasing oxidising ability ↓

Increasing reducing ability ↑