SOUTH AFRICAN AGENCY FOR SCIENCE AND TECHNOLOGY ADVANCEMENT

PHYSICS OLYMPIAD

GRADE 10 - 11

2023

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 20 pages and 5 data sheets.

Three hours are allowed to answer the questions

1. What mass of 92% pure $CaCO_3$ will be required to neutralize 40 ml of a 0,3 mol.dm^{-3} HCl solution? The reaction is:

$CaCO_3(s) + 2\,HCl(aq) \rightarrow CaCl_2(aq) + CO_2(g) + 2\,H_2O(l)$

A. 0,55 g
B. 0,65 g
C. 1,30 g
D. 65 g

2. The compound containing both covalent and ionic bonds is …

A. Al_2O_3
B. CO_2
C. NH_4Cl
D. Na_2O

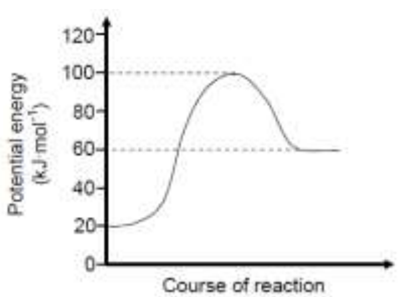
3. The acid that causes muscle cramps in athletes is …

A. Acetic acid
B. Citric acid
C. Lactic acid
D. Nitric acid

4. Which ONE of the following is a CORRECT description for a 0,1 mol·dm^{-3} hydrochloric acid solution?

A. Dilute strong acid
B. Dilute weak acid
C. Concentrated weak acid
D. Concentrated strong acid

5. Consider the following potential energy diagram for a chemical reaction:



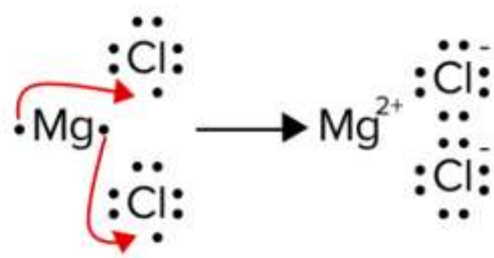
Which ONE of the following shows the values of the total energy change and the activation energy for this reaction?

6. Which of the following has the highest mass?

	Energy change (kJ·mol^{-1})	Activation energy (kJ·mol^{-1})
A	80	40
B	60	100
C	40	80
D	– 40	80

A. 3,011 x 10^{23} atoms of magnesium
B. 10 g of carbon
C. 11,2 dm^2 nitrogen gas at STP (standard temperature and pressure)
D. NaCl in a 100 ml solution with a concentration of 1 mol.dm^{-3}.

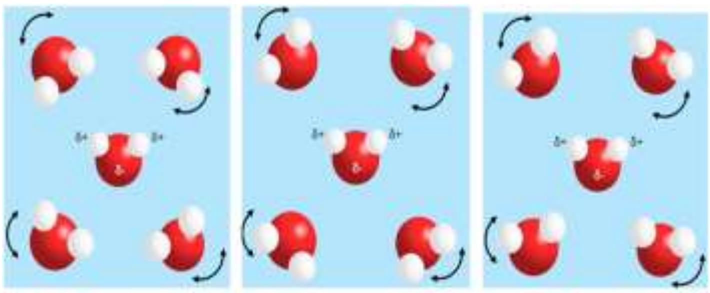
7. The Lewis structure for the formation of magnesium chloride is shown below.



Which of the following energy requirements is correct for the reaction?

	When valence electrons are removed from magnesium	When valence electrons are added to chlorine
A	Energy is required	Energy is released
B	Energy is released	Energy is required
C	Energy is required	Energy is required
D	Energy is released	Energy is released

8. Water molecules are dipoles attracted to each other by intermolecular forces called hydrogen bonds.



I II III

In which of the illustrations above do all the outer water molecules have the correct orientation to form hydrogen bonds with the central water molecule?

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

9. Which of the following is a decomposition reaction?

A. $2Na + Cl_2 \rightarrow 2NaCl$
B. $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$
C. $2H_2O \rightarrow 2H_2 + O_2$
D. $2K + 2H_2O \rightarrow 2KOH + H_2$

10. Which one of the following is not a physical property of matter?

A. Density
B. Boiling point
C. Acidity
D. Hardness

11. Which of the two elements below will be a liquid at room temperature (and atmospheric pressure)?

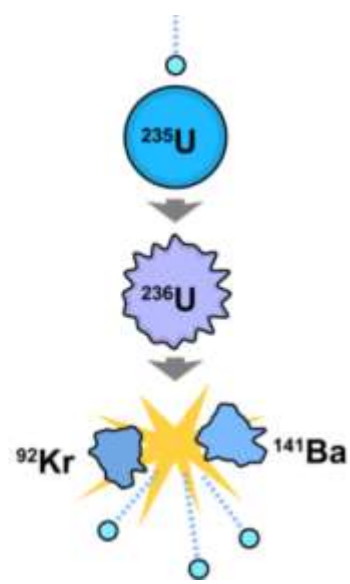
A. Mercury and bromine
B. Potassium and chloride
C. Mercury and chloride
D. Potassium and bromide

12. In many parts of the world, table salt is obtained from sea water using heat from the sun.

Which separation method is used here?

A. Filtration
B. Chromatography
C. Distillation
D. Evaporation

13. The illustration shows the basic nuclear fission process used to generate electricity. A particle collides with an atom of U-235. Momentarily, a U-236 atom forms which then splits into two smaller atoms (Kr-93 and Ba-141) in the diagram. This process results in the release of three new particles, which can then initiate fission reactions with more atoms.



The three new particles released during the reaction are …

A. Electrons
B. Protons
C. Neutrons
D. Alpha particles

14. The ideal gas law equation can be manipulated to show the relationship between the density and the molecular mass of a gas. Calculate the density of oxygen gas at a pressure of 5 atm and a temperature of 27 °C. The density is … g.dm^{-3}.

A. 3,25
B. 6,5
C. 0,064
D. 224,37

15. Hydrogen carbonate ions react with water according to the following balanced equation:

HCO_3^- (aq) + H_2O(ℓ) ⇌ H_2CO_3(aq) + OH^- (aq)

The formulae for the two acids in the above equation is:

A. HCO_3^- and H_2O
B. H_2CO_3 and OH^-
C. HCO_3^- and H_2CO_3
D. H_2O and H_2CO_3

16. In 2005 South Africa became an associate member of the Joint Institute for Nuclear Research (JINR). The last heavy metal element on the periodic table, element 118, was synthesized at the JINR laboratory in 2002 and named oganesson (Og).**In which country is the headquarters of JINR?**

A. Russia
B. USA
C. Switzerland
D. Germany

17. **A group of learners investigate Boyle's Law. Which of the following indicates the variables for their experiment correctly?**

	INDEPENDENT VARIABLE	**DEPENDENT VARIABLE**	**CONTROLLED VARIABLE**
A	Pressure	Temperature	Volume
B	Pressure	Volume	Temperature
C	Volume	Pressure	Temperature
D	Temperature	Volume	Pressure

18. Which of the following shows the correct properties of NH_3 and CO_2?

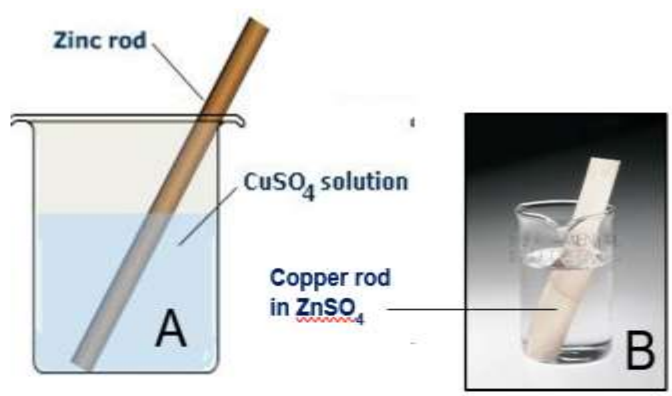
	Ammonia (NH_3)		**Carbon dioxide (CO_2)**	
	Molecular shape	**Intermolecular forces**	**Molecular shape**	**Intermolecular forces**
A	Trigonal pyramidal	Dipole-dipole	Linear	London
B	Trigonal pyramidal	Hydrogen bonds	Linear	London
C	Angular	Dipole-dipole	Angular	Dipole-dipole
D	Angular	Hydrogen bonds	Angular	Dipole-dipole

19. Ethyl ethanoate is an organic molecule with a characteristic strong paint smell. The molecule consists of 54.55% carbon, 9.09% hydrogen and 36.36% oxygen atoms and weighs 88 g.mol^{-1}.

The molecular formula for ethyl ethanoate is …

A. C_2H_4O
B. $C_4H_8O_2$
C. C_4H_4O
D. C_4H_4O

20. Beaker A shows a zinc rod placed in a copper (II) sulphate solution. Beaker B shows a copper rod placed in a zinc sulphate solution.

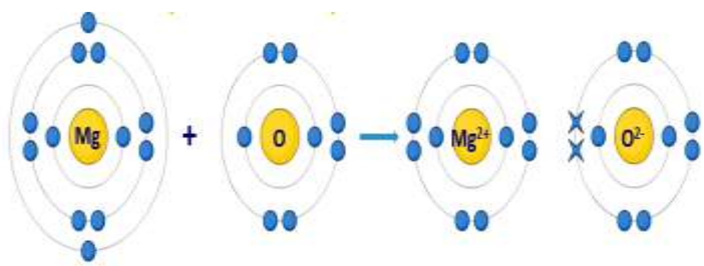


Which of the following will be observed in the beakers after a while?

I. The rod will be eroded
II. The colour of the solution will change
III. The temperature of the solution will decrease
IV. No changes will be observed

	BEAKER A	BEAKER B
A	I, II & III	IV
B	I, II & III	I, II & III
C	I & II	IV
D	IV	I & II

21. Magnesium reacts with oxygen. The electron transfer is shown below.

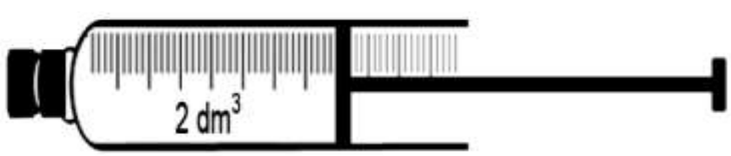


Which of the following is true for this reaction?

I. Mg is oxidized
II. O_2 is the oxidizing agent
III. A covalent bond will form between the atoms

A. I only
B. I & II
C. I, II & III
D. None

22. Dinitrogen tetroxide, $N_2O_4(g)$, decomposes to nitrogen dioxide, $NO_2(g)$, in a sealed syringe of volume 2 dm³.



The mixture reaches equilibrium at 325 °C according to the following balanced equation:

$$N_2O_4(g) \rightleftharpoons 2\,NO_2(g)$$

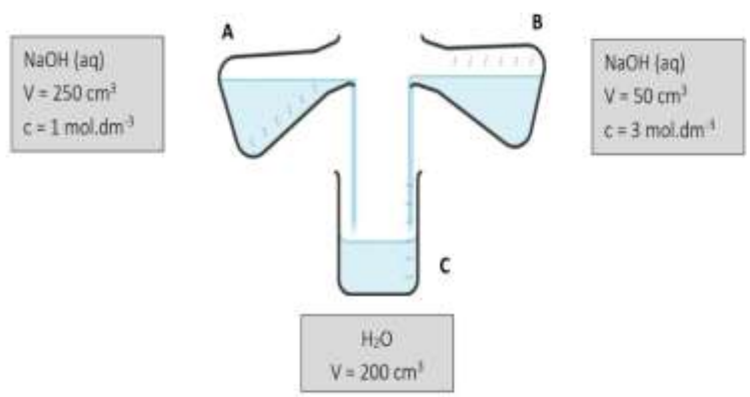
Colourless Brown

When equilibrium is reached, it is observed that the colour of the gas in the syringe is brown. The syringe is now dipped into a beaker of ice water. After a while the brown colour disappears. Which of the following is correct?

	FORWARD REACTION	NUMBER OF MOLES OF N_2O_4
A	Endothermic	Increase
B	Endothermic	Decrease
C	Exothermic	Increase
D	Exothermic	Decrease

23. Two Erlenmeyer flasks with different solutions of sodium hydroxide is poured into beaker C, already containing 200 cm³ distilled water.

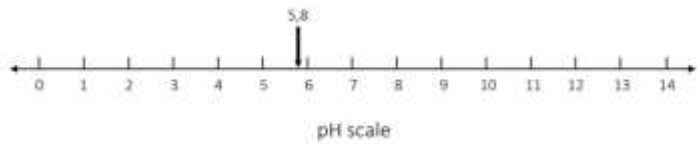
Flask A contain 250 cm³ NaOH with concentration 1 mol.dm^{-3}
.
Flask B contain 50 cm³ NaOH with concentration 3 mol.dm^{-3}



The concentration of the final solution will be …

A. 0,4 mol.dm^{-3}
B. 0,8 mol.dm^{-3}
C. 1,0 mol.dm^{-3}
D. 2,0 mol.dm^{-3}

24. What will the colours of the following indicators be in a solution with a pH = 5.8?



	METHYL ORANGE (3,1 – 4,4)	BROMOTHYMOL BLUE (6,0 – 7,6)	PHENOLPHTHALEIN (8,3 – 10)
A	YELLOW	BLUE	PINK
B	RED	YELLOW	TRANSPARENT
C	YELLOW	YELLOW	TRANSPARENT
D	RED	BLUE	PINK

READ THE FOLLOWING PARAGRAPH AND ANSWER QUESTIONS 25 TO 27.

Airlander, the new airship of the 21st century, can carry heavier loads farther and cheaper than helicopters can, with lower emissions than fixed-wing aircraft—potentially zero emissions, if the ships are powered by hydrogen fuel cells. Although hydrogen is used to propel the ship forward, helium is now used as lifting gas in place of the reactive hydrogen to fill the huge body of the ship to prevent explosions.

Hydrogen fire destroys Hindenburg, May 6, 1937

25. Which of the following is the correct overall reaction of a hydrogen-oxygen fuel cell?

A. $2H_2O \rightarrow 2H_2 + O_2$

B. $2H_2 + O_2 \rightarrow 2H_2O$

C. $H_2 + O_2 \rightarrow H_2O_2$

D. $O_2 + 2H_2O \rightarrow 4OH^-$

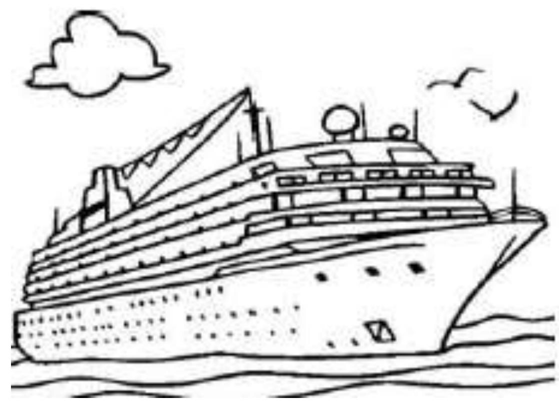
26. Which one of the following is the main reason that hydrogen gas was replaced by helium gas?

A. Helium is cheaper than hydrogen
B. Helium is lighter than hydrogen
C. Helium is less reactive than hydrogen
D. Helium is more abundant than hydrogen

27. Which of the following is true for helium gas?

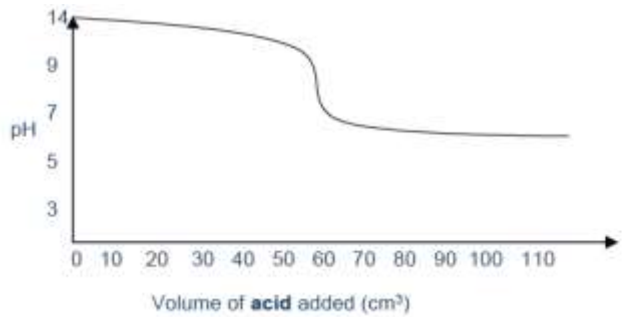
A. It is lighter than hydrogen gas
B. It has the same mass as hydrogen gas
C. It is twice as heavy as hydrogen gas
D. It is 4 times heavier than hydrogen gas

28. A boat floats in water because …



A. The air that is inside a ship is much less dense than water
B. The metal the boat is made of has a lower density than water
C. The water displaced by the boat is heavier than the boat itself
D. The width of the boat is more than its height.

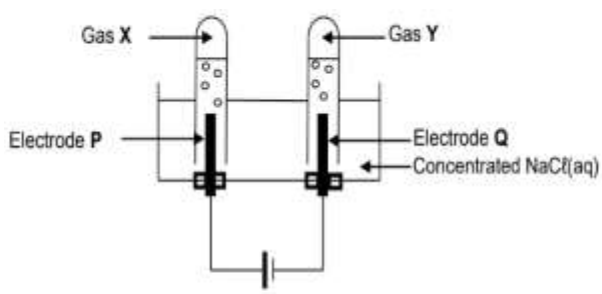
29. The graph (not drawn to scale) for pH versus volume for the titration of an unknown acid with a base was obtained, which ONE of the following combinations of base and acid best fits the graph?



A. Strong acid – weak base
B. Weak acid – strong base
C. Strong acid – strong base
D. Weak acid – weak base

30. In the electrochemical cell below, carbon electrodes are used during the electrolysis of a concentrated sodium chloride solution. The balanced equation for the net (overall) cell reaction is:

$2H_2O(l) + 2Cl^-(aq) \rightarrow Cl_2(g) + H_2(g) + 2OH^-(aq)$



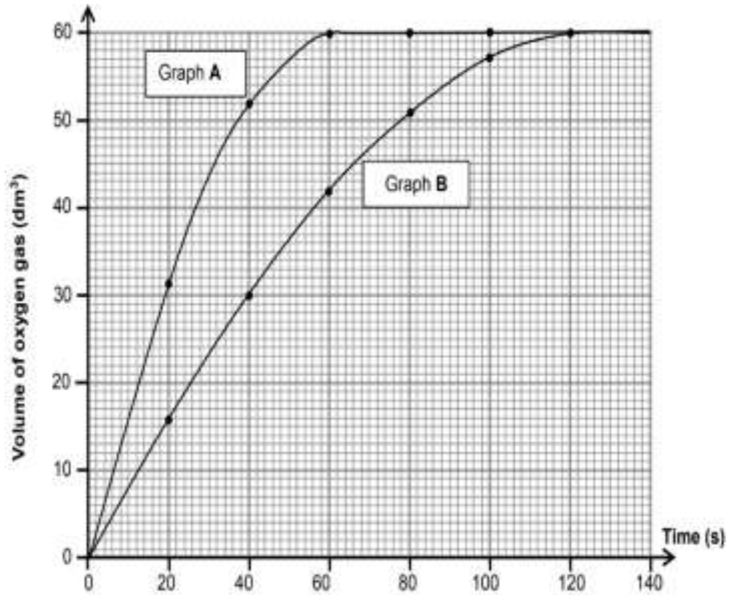
Which of the following is correct?

	Electrode P	Gas Y	pH of solution after reaction completion
A	Anode	Chlorine	<7
B	Anode	Hydrogen	>7
C	Cathode	Hydrogen	>7
D	Cathode	Chlorine	<7

31. Hydrogen peroxide, H_2O_2, decomposes to produce water and oxygen according to the following balanced equation:

$2H_2O_2(l) \rightarrow 2H_2O(l) + O_2(g)$

Graphs A and B below were obtained for the volume of oxygen produced over time at different temperatures.



Which of the following statements are correct?

I. The rate of reaction for graph A is faster than for graph B
II. The mass of hydrogen peroxide used to obtain graph B was more compared to that used to obtain graph A
III. Graph A was obtained at a higher temperature than graph B

A. I & II
B. I & III
C. II & III
D. I, II & III

32. You are asked to determine the value of a golden-coloured cube handed to you.

You measure the cube and find that it is 2 cm on each side, and weighs 40 g. In a mineral table you find the following information:

.

	PYRITE (FOOL'S GOLD)	GOLD
DENSITY (g/cm^3)	5	19,3
PRICE PER GRAM	R 5.50	R 1 070

Your calculations will show that:

A. The cube is gold with a value of R 42 800
B. The cube is pyrite with a value of R 220
C. The cube is gold with a value of R 21 400
D. The cube consists of a mixture of gold and pyrite

33. Who among the following conceived the first recognizable periodic table of chemical elements?

A. John Dalton
B. Amedeo Avogadro
C. Dmitri Mendeleev
D. Marie Curie

34. Ethanoic acid is the main constituent of which of the following substances?

A. Soap
B. Vinegar
C. Wine
D. Orange juice

35. Which of these two gases are reactants in the Haber-Bosch process to manufacture ammonia?

A. Oxygen, sulphur
B. Carbon, nitrogen
C. Nitrogen, hydrogen
D. Sulphur, hydrogen

36. The occurrence of some chemical elements to exist in two or more different forms, in the same physical state is known as allotropes. Which of the following is not an allotrope of carbon?

A. Charcoal
B. Graphite
C. Zircon
D. Diamond

37. People suffering from acidity are given antacid tablets and these tablets most commonly contain which of the following salts?

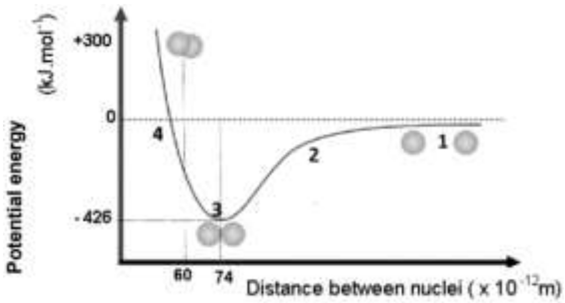
A. Copper (II) sulphate
B. Calcium hydroxide
C. Magnesium hydroxide
D. Sodium sulphate

38. Which of the following statements regarding the periodic table is correct?

I. Electron affinity increases from left to right and bottom to top
II. Atomic radius increases from right to left and top to bottom
III. Ionization energy increases from left to right and bottom to top

A. I & II
B. I & III
C. II & III
D. I, II & III

39. The graph below shows how the potential energy of two hydrogen atoms change as the distance between them changes.



Which of the following is correct?

	Bond energy (kJ.mol^{-1})	Bond length (x10^{-12} m)
A	- 426	74
B	- 126	74
C	+ 300	60
D	- 126	60

40. At sea level the boiling point of water is 100 °C. Johannesburg is approximately 1 700 m above sea level. The boiling point for water in Johannesburg in °C will be …

A. 94
B. 100
C. 102
D. 104

41. Which of the following is NOT a unit of temperature?

A. Celsius
B. Kelvin
C. Fahrenheit
D. mm Hg

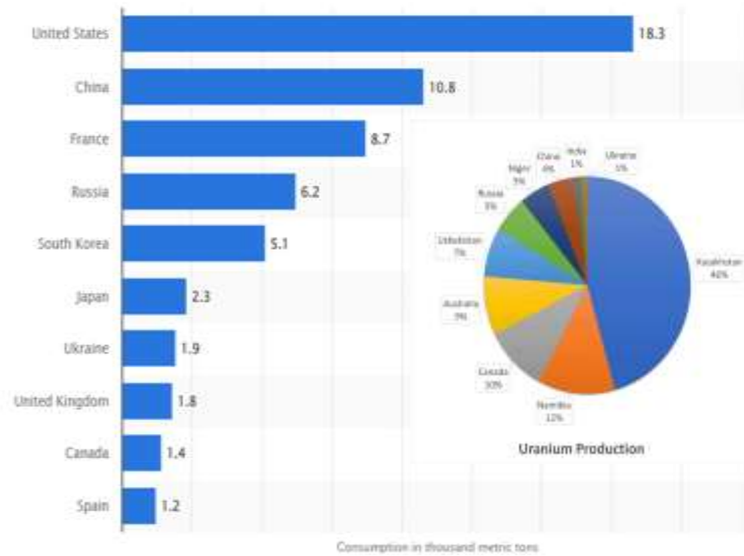
42. Three isotopes of carbon are shown below.

$^{12}_{6}C$ $\quad$ $^{13}_{6}C$ $\quad$ $^{14}_{6}C$

Which statement is correct?

A. They have the same half-life.
B. They have the same mass number.
C. They chemically react in the same way
D. They all emit radiation as they decay.

43. The bar graph below shows the consumption of uranium per country. The circle graph shows the production of uranium per country.



Which of the following statements are correct?

I. The radioactive isotope ^{235}U is needed to generate electricity through nuclear fission
II. Uranium is used in the development of military weapons such as submarines and atom bombs
III. Namibia is the biggest producer of uranium in Africa
IV. The United States of America relies on uranium imports to sustain their nuclear power sites

A. I, II & III
B. I, II & IV
C. II, III & IV
D. I, II, III & IV

44. Study the following substances:

HCl, Cl_2, H_2O, CO_2, HF

Which of the following indicates the correct intermolecular forces present in these substances?

	London forces	Hydrogen bonds	Dipole-dipole
A	Cl_2	H_2O & HF	CO_2 & HCl
B	Cl_2 & CO_2	H_2O & HF	HCl
C	Cl_2	H_2O	HF, CO_2 & HCl
D	CO_2	H_2O & HF	HCl, Cl_2

45. Which one of the following gases has the biggest volume at STP?

A. 20 g O_2
B. 10 g NH_3
C. 20 g H_2
D. 15 g SO_2

46. Marble is a metamorphic rock that is formed from limestone. The chemical formula for limestone is:

A. $Mg(OH)_2$
B. $Ca(OH)_2$
C. $MgCO_3$
D. $CaCO_3$

47. **The majority of Earth's freshwater is found in**:

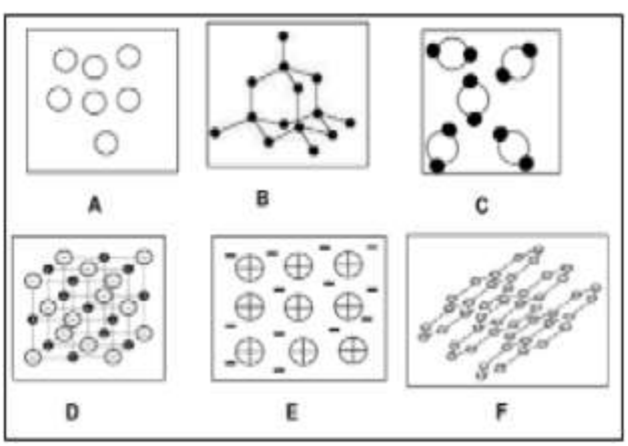
A. Glaciers and ice caps
B. Oceans
C. Rivers
D. Groundwater

48. Tectonic plates are large pieces of the Earth's lithosphere that move and interact with each other, causing geological activity such as earthquakes, volcanic eruptions, and the formation of mountain ranges.

Which of the following is used as a measurement of the amplitude of the vibration due to an earthquake?

A. Newton scale
B. Beaufort scale
C. Richter scale
D. Mohs scale

49. **Study the illustrations of the diagrams below**.



Which of the following correctly represents the letter of the illustration above?

	Diamond	Helium	Lithium chloride	Copper
A	F	A	D	E
B	F	C	E	A
C	B	A	D	E
D	B	A	E	A

50. **Study the following balanced equations**.

I. $Na_2CO_3(g) + 2HCl(aq) \rightarrow 2NaCl(aq) + H_2O(l) + CO_2(g)$

II. $Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$

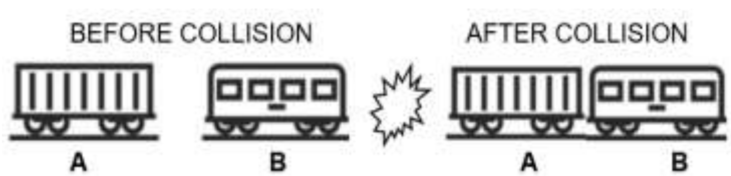
III. $H_2CO_3 \rightarrow H_2O + CO_2$

IV. $AgNO_3(aq) + KCl(aq) \rightarrow AgCl(s) + KNO_3(aq)$

Which of the following correctly indicate the type of the reactions above?

	I	II	III	IV
A	Gas forming	Acid-base	Decomposition	Ion exchange
B	Gas forming	Redox	Ion exchange	Precipitation
C	Acid-base	Redox	Decomposition	Ion exchange
D	Acid-base	Gas forming	Acid-base	Precipitation

51. A railway truck A, travelling along a level track at 5.0 m s^{-1} collides with a truck B of twice the mass moving in the same direction at 2.5 m s^{-1}. The trucks couple together and continue moving at a speed of 3,33 m.s^{-1}.



The percentage of the kinetic energy lost in the collision is …

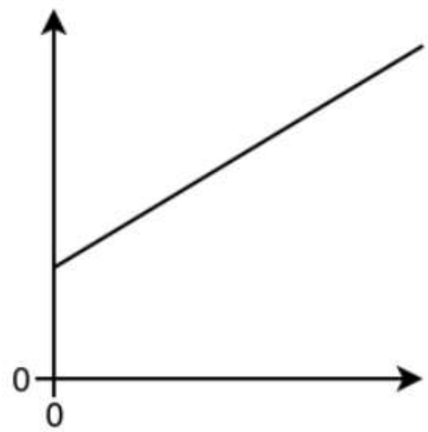
A. 0,11%
B. 11%
C. 0,44%
D. 4,4%

52. The momentum of an object is defined as the product of its mass and velocity. Units are in SI units.

The unit of momentum is ….

A. kg.m.s^{-1}
B. kg.m.s^{-2}
C. g.m.s^{-1}
D. g.m.s^{-2}

53. An object is moving at a constant acceleration of 5 m.s^{-2}.



The graph shows the …

A. displacement of the object over time.
B. distance of the object over time.
C. velocity of the object over time.
D. acceleration of the object over time.

54. Microwaves and UV-rays (ultra-violet rays) are both electromagnetic waves. Which of the following statements is correct?

I. UV-rays moves faster than microwaves
II. UV-rays have a higher frequency than microwaves
III. UV-rays have a longer wavelength than microwaves
IV. UV-rays have more energy than microwaves

A. II and III
B. II and IV
C. I, II and IV
D. I, III and IV

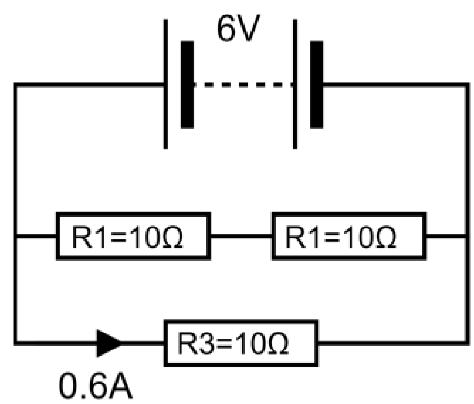
55. Which of the following statements is true?

I. Blue light has a higher frequency than green light
II. Television stations use radio waves to broadcast their signals
III. A red hot stove plate emits infra-red light
IV. X-rays can penetrate through human flesh and bones

A. I and II
B. I and III
C. I, II and III
D. I, II, III and IV

Consider the circuit shown below to answer both questions 56 and 57:

Each of the fixed resistors has a value of 10 Ω. A current of 0.6 A flows through resistor R3.



56. The total current flowing through the battery is:

A. 0.6 A
B. 0.9 A
C. 1.2 A
D. 1.8 A

57. The power dissipated by resistor R3 is:

A. The same power as dissipated by resistor R1
B. 2 x the power dissipated by resistor R1
C. 3 x the power dissipated by resistor R1
D. 4 x the power dissipated by resistor R1

58. An out of control model rocket accelerates vertically downwards at 12 m/s^{-2}. The mass of the rocket is 8 kg. Ignore air resistance.

The thrust from the rocket engine is:

A. 0 N
B. 17,6 N
C. 78,4 N
D. 96 N

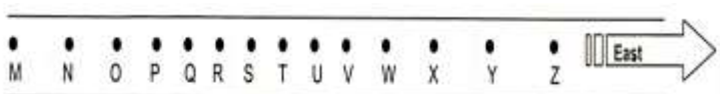
59. **In a science experiment an insulated block of metal is heated using an electric heater for 10 minutes. The mass of the block is 900 g. The initial temperature of the block is measured to be 17 °C and the final temperature is measured as 43 °C.**

The experiment is repeated using the same metal block and electric heater. This time the starting temperature is 19 °C and the block is heated for 15 minutes.

The final temperature of the metal block in the second experiment will be approximately:

A. 39 °C
B. 45 °C
C. 58 °C
D. 65 °C

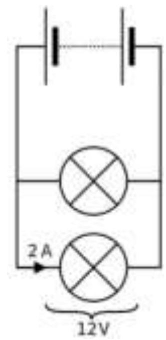
60. Oil dripping from a truck at equal time intervals leaves the pattern below on the road.



If the truck is moving eastwards, which ONE of the combinations below best describes the speed of the truck during the intervals M to Q, Q to V and V to Z?

	M TO Q	Q TO V	V TO Z
A	Decreases	Remains constant	Increases
B	Increases	Remains constant	Decreases
C	Remains constant	Increases	Increases
D	Increases	Decreases	Remains constant

61. A battery and two identical bulbs are connected in parallel. The current through each bulb is 2 A and the potential difference across each bulb is 12 V.



The battery voltage and current through the battery are:

	Battery voltage / V	Current through battery / A
A	12	2
B	12	4
C	24	2
D	24	4

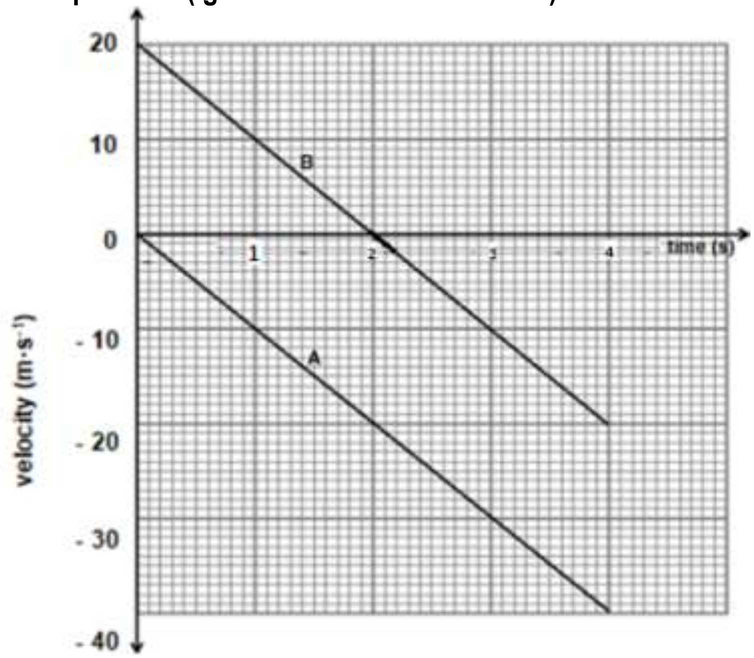
62. The specific heat capacity of copper is 385 J/(kg °C) which means that 385 Joules of thermal energy are needed to raise the temperature of 1 kg of copper by 1 °C. The melting point of copper is 1085 °C. How much thermal energy is needed to raise 50.0 grams of copper wire to its melting point when it is initially at a temperature of 20.0 °C?

A. 20.9 MJ
B. 20.5 MJ
C. 20.9 kJ
D. 20.5 kJ

63. Without any stoppage a person travels a certain distance at an average speed of 42 km/h. With stoppages he covers the same distance at an average speed of 28 km/h. On average, how many minutes per hour is lost due to stoppages?

A. 14 minutes
B. 15 minutes
C. 20 minutes
D. 28 minutes

64. The velocity-time graph shown below represents the motion of two objects, A and B, released from the same height. Object A is released from REST and at the same instant object B is PROJECTED vertically upwards. (Ignore the effects of friction.)

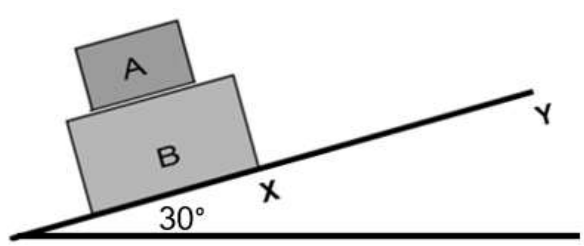


Calculate, WITHOUT USING EQUATIONS OF MOTION, the distance between objects A and B at t = 1 s. The distance is …

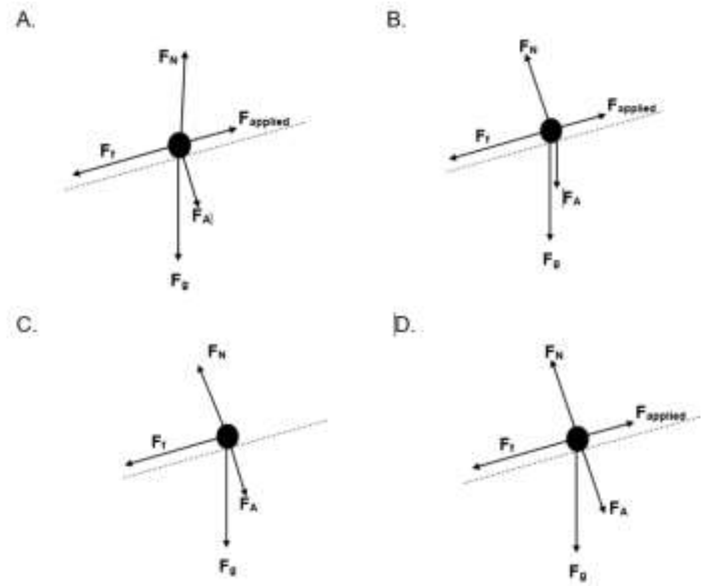
A. 4 m
B. 20 m
C. 0,8 m
D. 16 m

Consider the following information and answer questions 65 to 67.

Crate **A** with mass 1 kg is stacked on top of crate **B** with mass 3 kg. The blocks SLIDE up a ramp and passes point **X** with a velocity of 2 m.s^{-1} and comes to rest at point **Y**. Assume block **A** does not move in relation to block B.



65. Which of the following free-body diagrams is the correct presentation of the forces acting on block B?



66. Which of the following equations is correct?

A. $F_N + F_A + mg.\cos 30° = 0$
B. $F_N + F_A + F_g = 0$
C. $F_N = - F_A – F_g$
D. $F_N = - F_A$

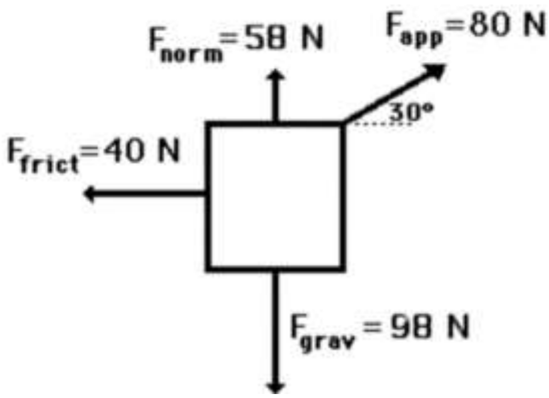
67. Which of the forces or their components in the free-body diagrams above is a pair of Newton III action-reaction forces?

A. F_N and F_A
B. F_N and $F_{g\perp}$
C. F_N and $mg.\cos 30°$
D. None of the above

Consider the following information and answer questions 68 to 69.

Consider the forces shown in the diagram exerted on a 10 kg block on a flat metal surface.

68. The magnitude of the acceleration of the block will be … m.s^{-2}



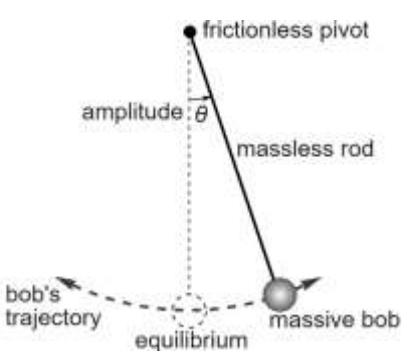
A. 0
B. 2,93
C. 10
D. 67,90

69. The value of the coefficient of kinetic friction (μ_k) for the metal surface is …

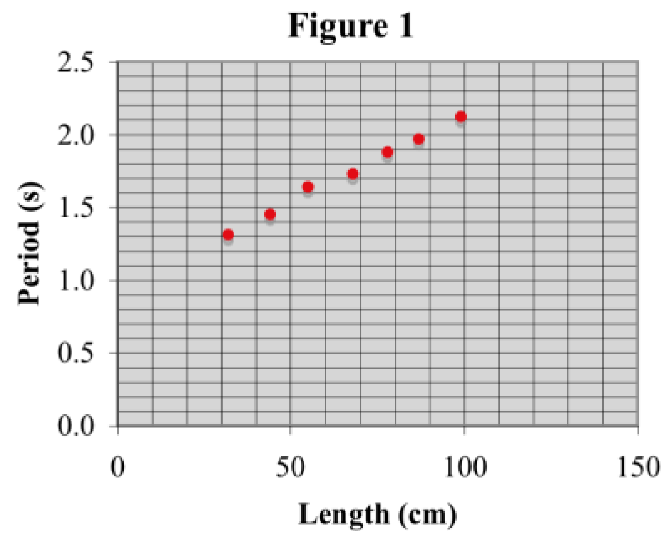
A. Zero
B. 0,41
C. 0,69
D. 1,37

Consider the following information and answer questions 70 to 73.

A pendulum is a weight suspended from a pivot so that it can swing freely as shown in the diagram.



A group of students are investigating one of the factors that might affect the period of a pendulum. The students make a pendulum by hanging a 200 g mass on the end of a string. They pull the mass back such that it makes an angle of 30° with its usual vertical orientation. They then release the mass, allowing it to swing back and forth. They use a stopwatch to measure the time it takes the pendulum to complete five full swings. They use this time to determine the period. They vary the length of the string while keeping the mass and angle constant. A plot of their data is shown in **Figure 1**.



70. Why did the students measure the time for five complete swings?

A. The period is the time it takes to make five complete swings.
B. The experiment doesn't take much time and they didn't want to be idle.
C. Since each experiment included five trials, they needed to be consistent by timing five complete swings.
D. Calculating the period from the time for five swings reduces error by providing an average of five periods.

71. What was the control variable(s) in the experiment?

A. Length
B. Period
C. Length and period
D. Mass and angle

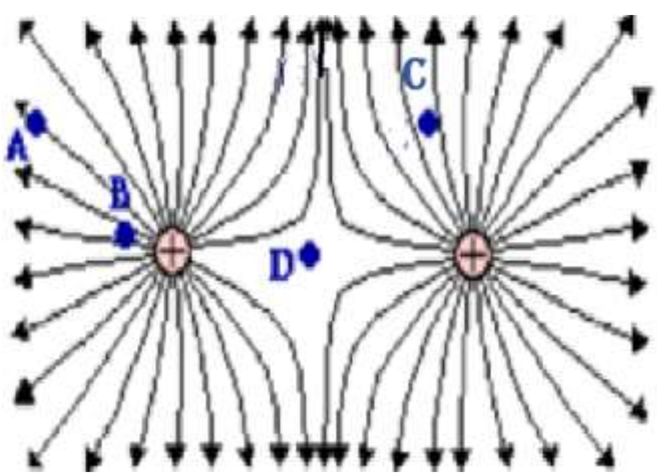
72. Which statement describes the effect of increasing length upon the period of a pendulum?

A. An increase in the length has no effect upon the period of a pendulum.
B. An increase in the length causes the period of a pendulum to increase.
C. An increase in the length causes the period of a pendulum to decrease.
D. As length increases, the period of a pendulum first increases and later decreases.

73. A 130-cm length pendulum consisting of a 200 g mass is released from an angle of 30°. Assume the relationship between length and period shown in Figure 1 can be extrapolated beyond a length of 100 cm. What is a reasonable estimate of this pendulum's period?

A. 2.12 seconds
B. 2.55 seconds
C. 3.30 seconds
D. 3.40 seconds

74. The diagram illustrates the electric field lines between two positive charges.

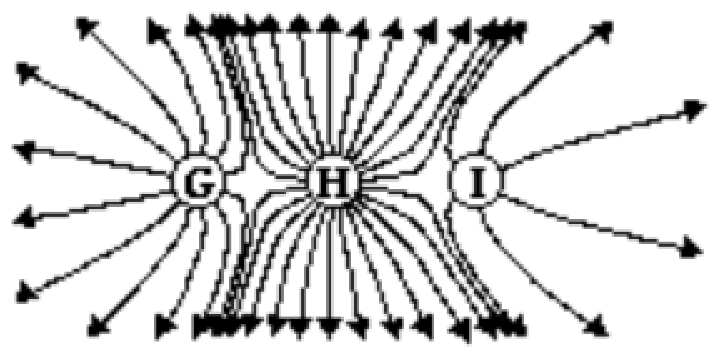


Which of the following is correct for the electrostatic force exerted on a unit positive charge situated at the points as indicated on the diagram?

The force will be …

A. The same at all the points
B. Strongest at **D** and weakest at **A**
C. Strongest at **C** and weakest at **D**
D. Strongest at **B** and weakest at **D**

75. The diagram illustrates the electric field lines between three charges.



Which of the following is correct for the charges G, H and I in the diagram?

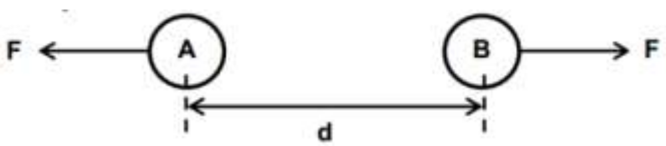
A. All three are positive
B. All three are negative
C. **H** is positive, **G** and **I** are negative
D. **H** is negative, **G** and **I** are positive

76. Two charges of +2 nC and -2 nC are located on a straight line. S and T are two points that lie on the same straight line as shown in the diagram below.

Which ONE of the following correctly represents the directions of the RESULTANT electric fields at S and at T?

	DIRECTION OF THE RESULTANT ELECTRIC FIELD AT POINT S	DIRECTION OF THE RESULTANT ELECTRIC FIELD AT POINT T
A	Left	Right
B	Right	Right
C	Left	Left
D	Right	Left

77. Three identical conducting spheres A, B and C are placed on insulated wooden stands. Spheres A and B carry equal charges. They are separated by a distance d and exert a force with magnitude F on each other, as shown in the sketch below.



The third sphere C, which is uncharged, touches A, then B, and is then removed. If the distance between the spheres remains the same, then the magnitude of the electrostatic force exerted on sphere B is now:

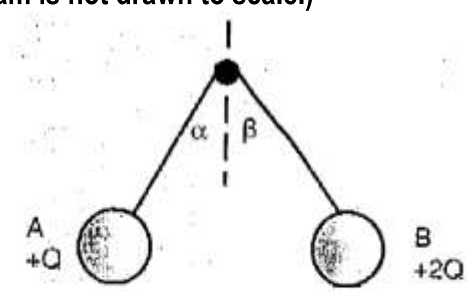
A. $\frac{F}{2}$

B. $\frac{F}{4}$

C. $\frac{3F}{8}$

D. $\frac{F}{16}$

78. Sphere A, with a charge of +Q, and sphere B, with a charge of +2Q, are suspended from the same insulated point as shown in the diagram below (the diagram is not drawn to scale.)



The spheres are allowed to move freely until they come to rest on their own.

How will the values of the angles α and β compare to each other once the spheres come to rest?

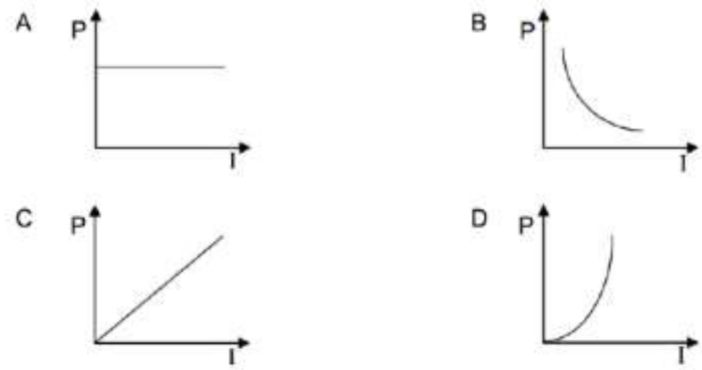
A. α=β

B. α<β

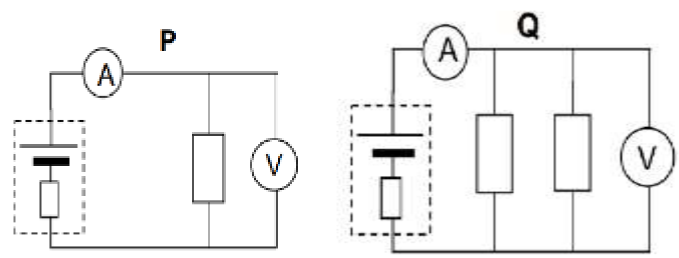
C. α>β

D. α=β=0

79. Which ONE of the following graphs best represents the relationship between the electrical power and the current in a given ohmic conductor?



80. In the circuits shown below all resistors and cells are identical.

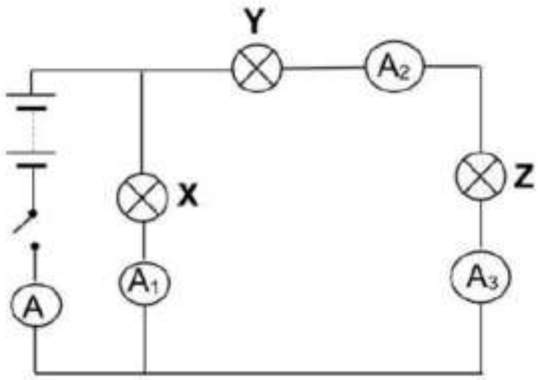


Which ONE of the following gives the correct comparison between the voltmeter and ammeter readings in circuit P and Q.

	VOLTMETER READING	AMMETER READING
A	$V_P > V_Q$	$A_P > A_Q$
B	$V_P > V_Q$	$A_P < A_Q$
C	$V_P < V_Q$	$A_P = A_Q$
D	$V_P = V_Q$	$A_P < A_Q$

81. Three light bulbs, X, Y and Z, are connected in a circuit as shown below. X and Y are identical, and both has a resistance R, while the resistance of Z is 2R. The battery has negligible internal resistance.

When switch S is closed, all the bulbs glow. The reading on ammeter A is 2,0 A.

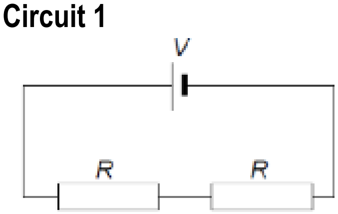


Which ONE of the following correctly describes the readings on the ammeters (in amperes) when bulb Z burns out?

	A_1	A_2	A_3	A
A	2	0	0	2
B	1,5	0	0	1,5
C	0,5	0,5	0	1
D	0,2	0,2	0,2	0,6

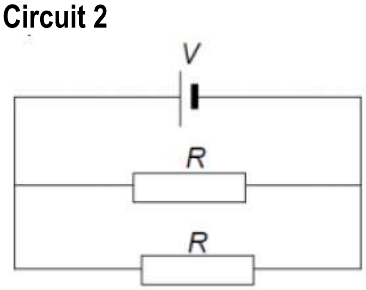
82. The two resistors in circuit 1 below are identical. They are connected in series to a cell of emf *V* and negligible internal resistance. The power dissipated by each resistor is *P*.

Circuit 1



The two resistors are now connected in parallel, as shown in circuit 2 below.

Circuit 2



The power dissipated by each resistor in circuit 2 is …

A. 2P
B. 4P
C. 8P
D. 16P

83. Calculate the total CHARGE transferred when 12 g magnesium is converted to magnesium ions?

A. $1,9 \times 10^{-18}$ C
B. $3,84 \times 10^{-18}$ C
C. $4,82 \times 10^{4}$ C
D. $9,63 \times 10^{4}$ C

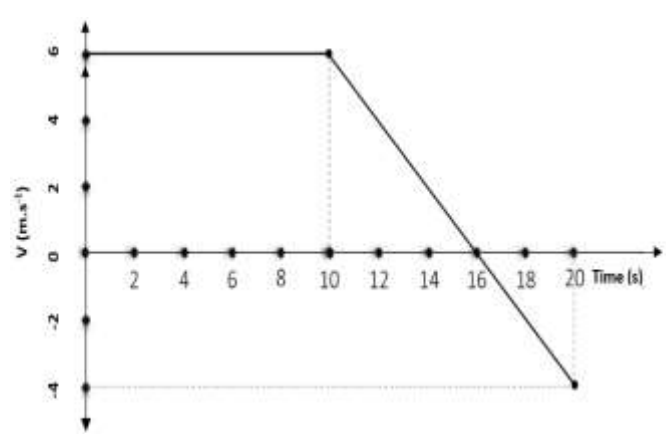
84. The rate of flow of charge in a circuit is equal to the:

A. Resistance
B. Potential differences
C. Power
D. Current

85. Three forces (1N, 2N and 2N respectively) act parallel to a frictionless surface on a crate. Which ONE of the following could NOT be a net force of the system?

A. 1 N
B. 2 N
C. 3 N
D. 5 N

86. Consider the following motion graph of an object that initially moves to the right.



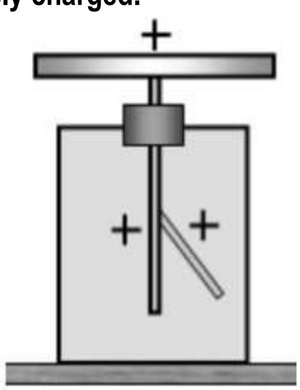
Which ONE of the following statements regarding the object's motion is FALSE?

A. The object's displacement after 10 seconds is 60 m to the right.
B. The object's displacement after 16 seconds is 78 m to the right.
C. The object's displacement after 20 seconds is 70 m to the left.
D. The total distance traveled by the object in 20 seconds is 86 m.

87. A light ray is refracted when it travels from air into water. Which ONE of the following combinations relating to the DIRECTION OF THE REFRACTED RAY and the SPEED OF THE LIGHT RAY is CORRECT?

	DIRECTION OF THE REFRACTED RAY	SPEED OF THE LIGHT RAY
A	Towards the normal	Decreases
B	Away from the normal	Decreases
C	Towards the normal	Increases
D	Away from the normal	Increases

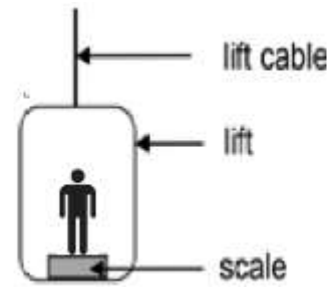
88. The leaves of the electroscope in the diagram below are positively charged.



When an object is brought close to the plate, the leaves diverge more. We can therefore conclude that the object ...

A. is positively charged.
B. is negatively charged.
C. is not charged at all.
D. releases positive charges.

89. A person stands on a bathroom scale that is fixed to the floor of a lift, as shown in the diagram below.

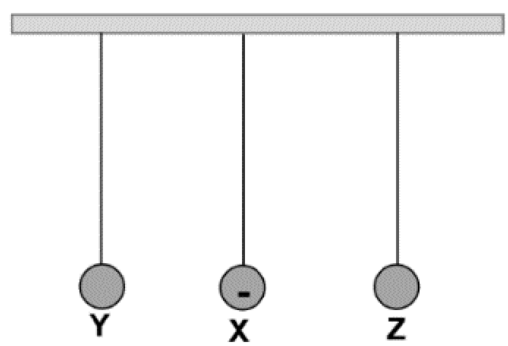


The reading on the scale is largest when the lift moves ...

A. upwards at a constant speed.
B. downwards at a constant speed.
C. upwards at an increasing speed.
D. downwards at an increasing speed.

90. Three charged spheres X, Y and Z, supported by insulating threads of equal length, hang from a beam, as shown in the diagram below.

Sphere X is negatively charged.
Sphere X attracts sphere Y, but repels sphere Z.



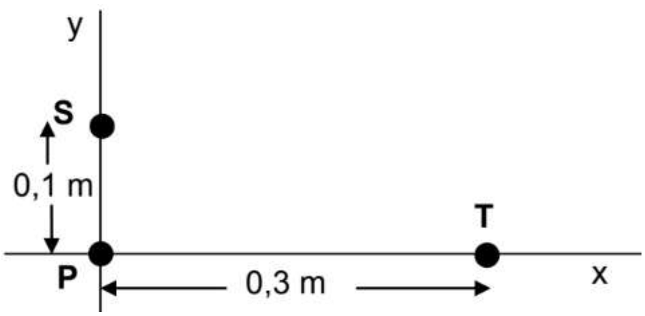
Which ONE of the following conclusions is CORRECT?

A. Sphere Y is positively charged and sphere Z is negatively charged.
B. Sphere Y is positively charged and sphere Z is positively charged.
C. Sphere Y is negatively charged and sphere Z is negatively charged.
D. Sphere Y is negatively charged and sphere Z is positively charged.

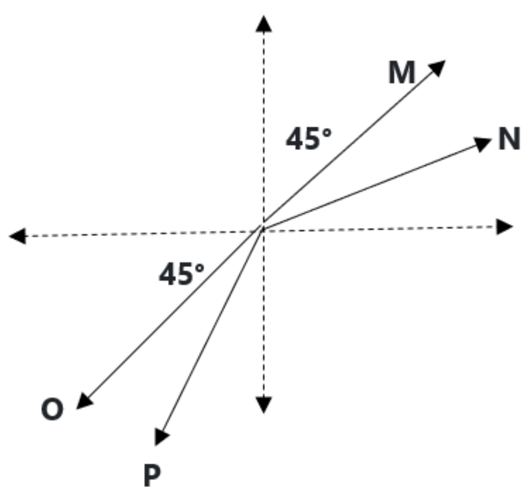
91. Which of the following is NOT a non-contact force?

A. Force of gravity
B. Electrostatic force
C. Normal force
D. Magnetic force

92. Three small identical metal spheres, P, S and T, each with a charge of -3×10^{-9} C, are placed at points on the x-axis and the y-axis, as shown in the diagram below, with sphere P at the origin.

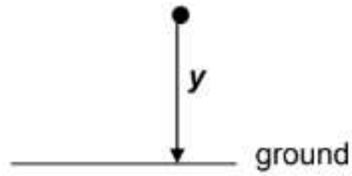


Which of the following (A, B, C or D) correctly indicates the direction of the resultant force experienced by sphere P?



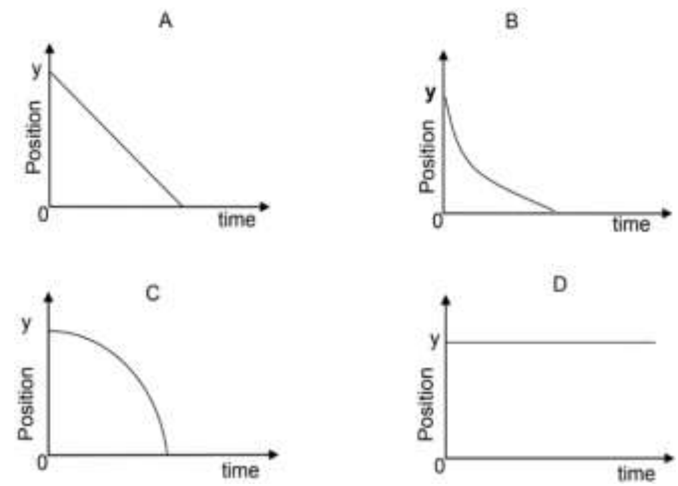
A. M
B. N
C. O
D. P

93. A small stone is dropped from a height y above the ground. It strikes theground after time t, as shown in the diagram below.



Take upwards as the positive direction and the ground as zero reference. Ignore the effects of air resistance.

Which ONE of the following diagrams shows a correct position-time graph for the motion of the stone?



94. The equation to show you the relationship between a satellite's velocity and the radius of the satellite's orbit is

$$v = \sqrt{\frac{GM}{r}}$$

Which of the following statements is true?

A. The speed of the satellite depends on its mass
B. A satellite orbiting nearer to the earth will have a higher speed than a satellite orbiting further from the earth
C. A satellite orbiting the moon will have a higher speed than a satellite orbiting the earth at the same distance from the surface
D. Satellites uses huge amounts of fuel to maintain their speed in orbit

95. An electrical component that allows the manual control of the flow of electric current by lowering or raising the resistance in a circuit is a …

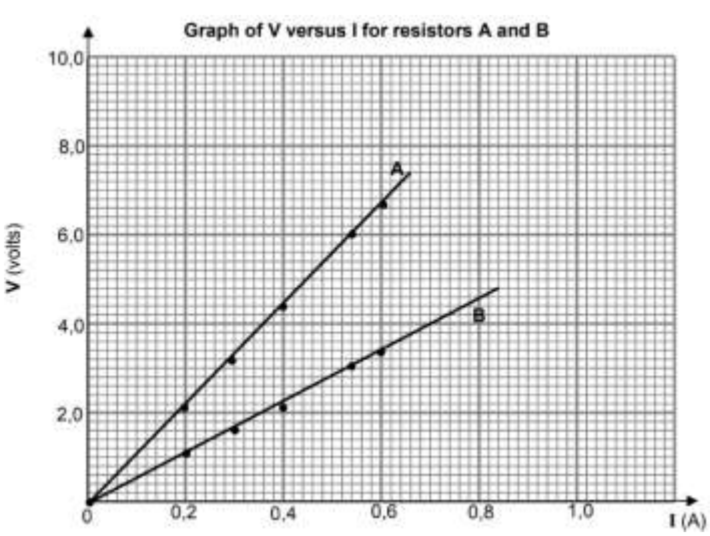
A. Resistor
B. Rheostat
C. Thermistor
D. Transistor

96. An inverter is an electrical device that can be connected to a solar panel to store energy in the form of an electric charge. The stored electric charge can then be used to supply power to your home during load shedding.

Such an inverter …

A. converts direct current (DC) electricity, which is what a solar panel generates, to alternating current (AC) electricity, which the electrical grid uses.
B. converts alternating current (AC) electricity, which is what a solar panel generates, to direct current (DC) electricity, which the electrical grid uses.
C. stores direct current (DC) electricity, which is what a solar panel generates, and provides direct current (DC) electricity, which the electrical grid uses.
D. stores alternating current (AC) electricity, which is what a solar panel generates, and provides alternating current (AC) electricity, which the electrical grid uses.

Consider the following information and answer questions 97 and 98.



Learners want to construct an electric heater using one of two wires, **A** and **B**, consisting of different materials. They conduct experiments and draw the graphs as shown.

97. Which of the following factors is NOT a constant variable for this investigation to ensure a fair test?

A. Temperature
B. Potential difference
C. Thickness of the wire
D. Length of the wire

98. From the graph, the respective resistance of wires A and B can be determined as …

A. 5,5 Ω and 11 Ω
B. 11 Ω and 5,5 Ω
C. 7,4 Ω and 4,8 Ω
D. 4,8 Ω and 7,4 Ω

99. The scientist who discovered production of electricity using a moving magnet and a coil is …

A. Marie Curie
B. Albert Einstein
C. Michael Faraday
D. Thomas Edison

100. The phenomenon when light changes direction and gets bended when travelling from air through a prism is called …

A. Diffraction
B. Reflection
C. Refraction
D. Interference

-----End-----

TABLE 1: PHYSICAL CONSTANTS

NAME	SYMBOL	VALUE
Acceleration due to gravity	g	$9{,}8\ m \cdot s^{-2}$
Universal gravitational constant	G	$6{,}67 \times 10^{-11}\ N \cdot m^2 \cdot kg^{-2}$
Radius of Earth	R_E	$6{,}38 \times 10^6\ m$
Mass of Earth	M_E	$5{,}98 \times 10^{24}\ kg$
Speed of light in a vacuum	c	$3{,}0 \times 10^8\ m \cdot s^{-1}$
Planck's constant	h	$6{,}63 \times 10^{-34}\ J \cdot s$
Coulomb's constant	k	$9{,}0 \times 10^9\ N \cdot m^2 \cdot C^{-2}$
Charge on electron	e	$-1{,}6 \times 10^{-19}\ C$
Electron mass	m_e	$9{,}11 \times 10^{-31}\ kg$

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

$F_{net} = ma$	$p = mv$
$f_s^{max} = \mu_s N$	$f_k = \mu_k N$
$F_{net}\Delta t = \Delta p$ $\Delta p = mv_f - mv_i$	$w = mg$
$F = G\dfrac{m_1 m_2}{d^2}$ or $F = G\dfrac{m_1 m_2}{r^2}$	$g = G\dfrac{M}{d^2}$ or $g = G\dfrac{M}{r^2}$

WAVES, SOUND AND LIGHT

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

ELECTRIC CIRCUITS

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

ALTERNATING CURRENT

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

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 $c=\frac{m}{MV}$	$n=\frac{V}{V_m}$
$\frac{c_aV_a}{c_bV_b}=\frac{n_a}{n_b}$	$pH = -\log[H_3O^+]$
$K_w = [H_3O^+][OH^-] = 1 \times 10^{-14}$ at 298 K	
$E^{\theta}_{cell} = E^{\theta}_{cathode} - E^{\theta}_{anode}$ or $E^{\theta}_{cell} = E^{\theta}_{reduction} - E^{\theta}_{oxidation}$ or $E^{\theta}_{cell} = E^{\theta}_{oxidising agent} - E^{\theta}_{reducing agent}$	

TABLE 3: THE PERIODIC TABLE OF ELEMENTS

KEY

Atomic number: 29
Electronegativity: 1,9
Symbol: Cu
Approximate relative atomic mass: 63,5

1 (I)	2 (II)	3	4	5	6	7	8	9	10	11	12	13 (III)	14 (IV)	15 (V)	16 (VI)	17 (VII)	18 (VIII)
1 2,1 H 1																	2 He 4
3 1,0 Li 7	4 1,5 Be 9											5 2,0 B 11	6 2,5 C 12	7 3,0 N 14	8 3,5 O 16	9 4,0 F 19	10 Ne 20
11 0,9 Na 23	12 1,2 Mg 24											13 1,5 Aℓ 27	14 1,8 Si 28	15 2,1 P 31	16 2,5 S 32	17 3,0 Cℓ 35,5	18 Ar 40
19 0,8 K 39	20 1,0 Ca 40	21 1,3 Sc 45	22 1,5 Ti 48	23 1,6 V 51	24 1,6 Cr 52	25 1,5 Mn 55	26 1,8 Fe 56	27 1,8 Co 59	28 1,8 Ni 59	29 1,9 Cu 63,5	30 1,6 Zn 65	31 1,6 Ga 70	32 1,8 Ge 73	33 2,0 As 75	34 2,4 Se 79	35 2,8 Br 80	36 Kr 84
37 0,8 Rb 86	38 1,0 Sr 88	39 1,2 Y 89	40 1,4 Zr 91	41 Nb 92	42 1,8 Mo 96	43 1,9 Tc	44 2,2 Ru 101	45 2,2 Rh 103	46 2,2 Pd 106	47 1,9 Ag 108	48 1,7 Cd 112	49 1,7 In 115	50 1,8 Sn 119	51 1,9 Sb 122	52 2,1 Te 128	53 2,5 I 127	54 Xe 131
55 0,7 Cs 133	56 0,9 Ba 137	57 La 139	72 1,6 Hf 179	73 Ta 181	74 W 184	75 Re 186	76 Os 190	77 Ir 192	78 Pt 195	79 Au 197	80 Hg 201	81 1,8 Tℓ 204	82 1,8 Pb 207	83 1,9 Bi 209	84 2,0 Po	85 2,5 At	86 Rn
87 0,7 Fr	88 0,9 Ra 226	89 Ac															

58 Ce 140	59 Pr 141	60 Nd 144	61 Pm	62 Sm 150	63 Eu 152	64 Gd 157	65 Tb 159	66 Dy 163	67 Ho 165	68 Er 167	69 Tm 169	70 Yb 173	71 Lu 175
90 Th 232	91 Pa	92 U 238	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

TABLE 4A: STANDARD REDUCTION POTENTIALS

Half-reactions			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