Science of Magic
EXAMINATION

Reading time: 10 minutes
Writing time: 90 minutes

Your name: _____

Teacher's initials: ____

Instructions:

1. All answers are to be written on the examination paper.
2. If you run out of room, or need to start your answer again, you may use the back of a page. Clearly indicate where this occurs.
3. Write your answers clearly.
4. There are *107* marks available in the examination. You should allocate approximately 1 minute per mark for each question.
5. You will not be permitted to leave the examination room until the scheduled completion of the exam.

ANSWER SHEET PART A:

NAME_____

1.	A	B	C	D	**18.**	A	B	C	D
2.	A	B	C	D	**19.**	A	B	C	D
3.	A	B	C	D	**20.**	A	B	C	D
4.	A	B	C	D	**21.**	A	B	C	D
5.	A	B	C	D	**22.**	A	B	C	D
6.	A	B	C	D	**23.**	A	B	C	D
7.	A	B	C	D	**24.**	A	B	C	D
8.	A	B	C	D	**25.**	A	B	C	D
9.	A	B	C	D	**26.**	A	B	C	D
10.	A	B	C	D	**27.**	A	B	C	D
11.	A	B	C	D	**28.**	A	B	C	D
12.	A	B	C	D	**29.**	A	B	C	D
13.	A	B	C	D	**30.**	A	B	C	D
14.	A	B	C	D	**31.**	A	B	C	D
15.	A	B	C	D	**32.**	A	B	C	D
16.	A	B	C	D	**33.**	A	B	C	D
17.	A	B	C	D	**34.**	A	B	C	D
					35.	A	B	C	D

Circle the correct response to each question on the answer sheet.

1) During magic shows we rely on our senses to give us an understanding of what we are seeing. One of the most important senses is sight. The eye has many nerve cells that are:

a) mainly, divided into cones and rods;
b) red cones and blue cones;
c) known as visual cells;
d) found only near the blind spot. In a place called the fovea..

Solution

2) Cilliary muscles help the eye to focus by:

a) moving the eye to different locations in the visual range.
b) changing the shape of the lens.
c) changing the shape of the retina.
d) relocating the blind spot.

Solution

3) Our brain is not as reliable as we think. Often we interpret our environment differently to reality. One such phenomenon is known as neural adaptation and is capable of creating powerful afterimages. Neural adaptation is best described as:

a) the eye changing its focus;
b) nerves that become adapted, over many thousands of year, to better process the signal they receive;
c) a persistent stimulus that fails to excite a nerve response ;
d) night vision.

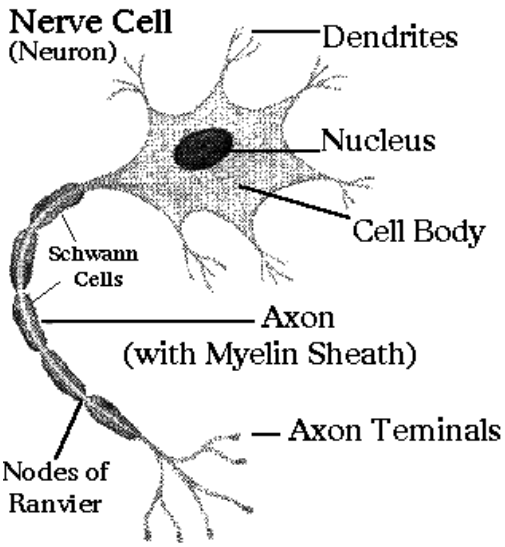
Solution

4) Motion sickness happens because the brain does its best to reconcile mismatching information whenever it can. Ventriloquists exploit this by shifting what you hear to what you see (the dummy's mouth.) This is an example of:

a) the brain's capacity to accurately deal with several inputs at once;
b) change blindness where the brain does not perceive what is going on around it;
c) an effect known as brain drain where the brain is simply overwhelmed;
d) the brain combining multisensory inputs to make sense of the environment.

5) On the right is a picture of a nerve cell. It has a unique shape ideal for:

a) keeping the brain matter firmly in place;
b) detecting light ;
c) protecting the brain from impact;
d) making multiple connections with other nerve cells



Solution

6) Which one of the following is true with regards to nerve cells?

a) The myelin sheath that covers the axon has no role to play in transmitting the signal.
b) The signal travels along the axon of the nerve cell from axon terminal to the cell body.
c) Nerve cells communicate with the use of chemicals.
d) Axon terminals receive information from other nerve cells.

Solution

7) The brain processes separate images coming from each eye to:

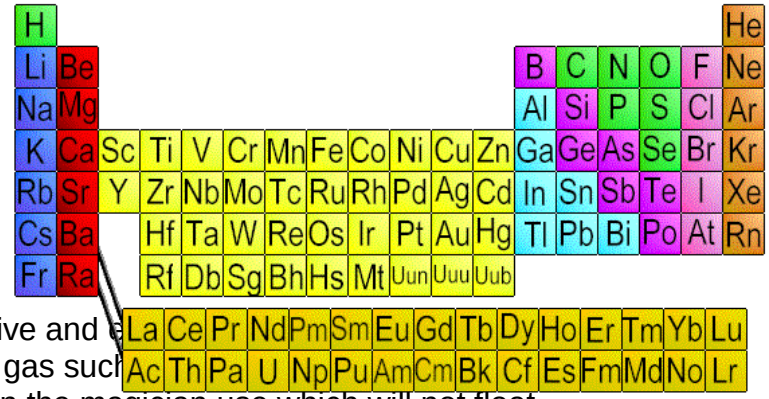
a) process the illusion of colour;
b) prevent partial and temporary blindness;
c) focus light onto the retina;
d) create a 3D image.

Solution

8) A magician wishes to use a chemical reaction to produce flames from water. Knowing that lithium metal will react with water to produce a flame, what other element can the magician also use?

a) Beryllium (Be)
b) Calcium (Ca).
c) Aluminum (Al).
d) Potassium (K)

Solution



9) A magician stores an extremely reactive and e
create smoke and fire, in a non-reactive gas such
light and floats away. What other gas can the magician use which will not float away?

a) Helium.
b) Oxygen.
c) Chlorine.
d) Argon.

Solution

10) Magicians use chemistry in clever ways to create illusions. A simple trick is to turn a clear liquid into wine. This is done by using a chemical known as an indicator. An indicator can best be described as a chemical that::

a) changes colour at different pH levels;
b) changes colour at different temperatures;
c) is always coloured, otherwise known as a dye;
d) reacts with water to produce a coloured solution.

Solution

11) The container on the right contains a green chemical that shows the presence of an acid or a base. Normally the chemical is green when placed in pure water. As shown on the right it is red at the top and changes to yellow and eventually green at the bottom. Which comment is true?

a) The solution is neutral.
b) The entire solution in the container is acidic.
c) This is indicates that the chemicals are not evenly mixed in the water.
d) All the liquid in the container is above pH 7.

12) A magician starts a fire by finely crushing potassium permanganate powder and adding a food additive known as glycerol. The glycerol burns quickly giving off a great deal of heat. Crushing the powder will increase the rate of the reaction. Which option below best explains why?

a) Before a reaction takes place reactant particles must collide with each other and crushing the powder increase the rate of collisions.
b) Crushing the powder increases the mass of reactant particles thus increasing the rate of reaction.
c) Crushing the powder increases the mass of products formed thus increasing the amount of energy released.
d) Crushing the powder decreases the number of collisions taking place during the reaction which allows the reaction to continue for longer thus creating more energy.

Solution

13) The magic of chemistry is best demonstrated by the Rags-to-riches trick, where a copper coin is magically changed into a gold coin. Firstly the copper coin is covered with zinc and once put on the flame turns to gold. Which one comment is true?

a) It is possible to use heat to change one metal into another if the right chemicals are present.
b) The gold coin should weigh more after the reaction since gold is heavier then both copper and zinc.
c) The zinc, once heated, helps the copper turn to gold.
d) Heating the copper with the layer of zinc help to mix the atoms of copper and zinc to form an alloy called brass.

Solution

14) The Genie-in-a-bottle trick uses a chemical reaction to generate steam quickly to simulate a genie escaping from the bottle. The reaction is given by the equation

$2H_2O_{2(aq)} \Rightarrow 2H_2O_{(g)} + O_{2(g)}$

Which comment below is true?

a) Liquid water and oxygen gas are produced.
b) Less mass exists after the reaction than before the reaction.
c. Hydrogen peroxide (H_2O_2),dissolved in water, decomposes to form gaseous products.
d) More mass exists after the reaction than before the reaction.

Solution

15) The Genie-in-a-bottle reaction, above, is started with the addition of a catalyst. Which statement is true?

a) A catalyst speeds up a reaction.
b) Catalysts increase the amount of heat produced by chemical reactions.
c) Catalysts increase the surface area for reaction to take places quickly.
d) Catalysts are used up during chemical reactions to form new products.

16) Starch and iodine are used to change a solution from clear to dark blue. Vitamin C is then placed in the solution to change the dark blue solution back to clear. Vitamin C acts as an antioxidant. Antioxidants take part in:

a) redox reactions that involve the transfer of electrons from one reactant to another;
b) increasing the rate of a chemical reaction;
c) reactions within the body to reduce the amount of oxygen used by the body during exercise;
d) chemical reactions within the body that involve the transfer of hydrogen (H^+) ions.

17) Magicians have many tricks up their sleeve when it comes to chemical reactions. One very dramatic reaction is the thermite reaction where rust is converted into pure iron with the use of aluminium powder. During this chemical reaction, as happens in all chemical reactions:

a) atoms are separated from each other and recombined to form new products;
b) new elements are created;
c) removal of heat energy reverses the reaction to form the original reactants;
d) new atoms are created which have different properties from the old atoms.

Solution

18) A very dynamic display of swirling colour takes place when food dye is placed in milk, as shown on the right, and a drop of detergent is added. Which one of the following options best describes why?

a)) The detergent increases the energy of the water causing the coloured dye to swirl around.
b) Detergents reduce the surface tension of water thus creating the swirling display.
b) Detergents increase the temperature of the water causing the colour to swirl quickly.
c) Detergent molecules do not mix with the water molecules instead mixing with the food dye and creating the colour display.

Solution

19) Magicians use explosive chemical reactions to produce a theatrical demonstration. A great deal of light, heat and gaseous products are produced during such reactions and the products expand quickly to create a stunning display. Which statement below best describes why the sudden expansion takes place?

a) Gas molecules accelerate quickly when heated .
b) Heat energy causes the gas molecules to fuse together into a tightly packed solid.
c) Gas molecules increase in size when they absorb heat and so expand violently.
d) Heat causes gas molecules to change colour while travelling at constant speed.

. Solution

20) Which one of the following comments is true about an explosive chemical reaction?

a) Converting the solid reactants of an explosive reaction into a powder form will not increase the speed of the reaction.
b) All explosive materials are in the form of liquids.
c) The products have no chemical energy as all the energy is converted to heat and light .
d) The products have less chemical energy than the reactants.
Solution

21) During an explosion energy appears to come from nowhere. Which statement is true?

a) Energy can be created during explosive chemical reactions only.
b) During an explosive chemical reaction chemical energy is converted into heat and light energy.
c) Energy cannot be stored but is created during all types of chemical reactions.
d) Mass is created during chemical reactions which produce solid products.
Solution

22) Magicians often use electrical energy to perform tricks. Electrical current can be used to generate forces that are not always visible to the audience. A current flowing through a conductor will produce:

a) an energy field;
b) energy;.
c) light;.
d) a magnetic field.
.Solution

23) A strong magnet is dropped though a copper pipe. It seems to defy gravity as it slowly descends down the tube. The explanation to this trick lies in Faraday's Law which states that

a) any change in the magnetic field that a coil of wire is placed in will result in the production of heat and light:
b) a current flowing through a conductor will produce heat;.
c) any change in the magnetic environment of a coil of wire will cause a voltage to be "induced" in the coil;
d) any change in the heat of a conductor will result in the generation of an electrical current.
Solution

24) Mirrors are used by magicians to create illusions. One such trick involves the floating-head illusion. This involves the use of flat mirrors to create a:

a) real image;
b) virtual image;
c) a magnified image;
d) an image that is diminished

.
Solution

25) A magician wishes to perform a trick that involves throwing knives at an assistant. The magician intends to produce an image of the assistant that is upright and slightly magnified. The magician should use a:

a) concave mirror to produce a virtual image;
b) concave mirror to produce a real image.
c) convex mirror to produce a real image;
d) convex mirror to produce a virtual image.

Solution

The information below is for question 26-29. A magician conducts a ball catching trick where the audience must react to a particular signal and catch a ball in mid-air. The magician conducts an investigation to find out the reaction time of certain people. He tests one person from each age group. The results are shown in the table below.

Age (years)	6	12	16	20	24	30	40	60
Reaction time (seconds)	6.0	4.0	3.0	1.0	2.0	4.0	5.0	7.0

26) The dependent variable is

a) age;
b) time;
c) the gender of the person being tested;
d) height.

27) How can this investigation be made more accurate?

a) Getting a stopwatch with a larger visual display..
b) Sampling more than one person per age group.
c) Allowing the participants to practice catching the ball before their reaction time is measured.
d) Conducting all the tests at the same time of day.

28) The magician wishes to use a 50 year old person for his trick. He needs to know the reaction time of the 50 year old person accurately. What method of representing the data is most likely to reveal a trend so that the magician can work out the reaction time of the 50 year old participant?

a) A tree graph
b) A 3D scatter plot.
c) Pie graph.
d) None of the above.

29) A colleague suggests that a line of best fit be drawn. In drawing this line the magician must take care to:

a) use a set of axis where the x-axis represents the reaction time in seconds:
b) draw a line and move the points so that they line up with this line;
c) always draw a straight line;
d) draw the line so that it comes close to as many points as possible.

Solution

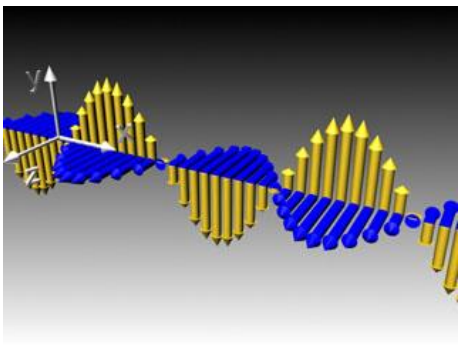
30) A researcher investigated how reaction time changes with height. He set up an investigation to test if tall people have longer reaction times compared to short people. The researcher selected 30 subjects over 1.90m tall and tested their reaction time to a light signal. Some participants were tested in low light conditions and some under bright light. He then analysed the data and concluded that there is no difference in the reaction time between short and tall people.

1) The same number of short and tall people should be tested.
2) All investigations should be conducted under the same light conditions.
3) Only 2 short and 2 tall people would be necessary to obtain accurate results.
4) A variety of tall people with different body masses must be used to get a better average.

Which of the above are necessary for a fairer test?

a) 1) only
b) 1) and 2).
c) 1), 2), 3) and 4)
d) 1), 2) and 3)

31) Many illusions involve the manipulation of light. Light is best described as electromagnetic radiation. Consider the image below. Which statement is true?



a) Light is formed from heat energy and electrical energy that travel in waves,
d) Light consists of two waves, a magnetic and a heat wave, that travel in different directions creating colour when they hit objects.
e) Light consists of yellow and blue wavelengths that interact with each other to form different colours.
d) Light consists of an electric field and a magnetic field that are perpendicular to each other

Solution

32) A nail protruding out of water, as shown on the right, creates the illusion of being bent. Which one of the following best explains why?

a) Light travels at the same speed as it passes from air into water.
b) This illusion only works if the water is hotter than the air around it because light travels faster in hot water than in cool air.
c) Light slows down as it goes from air into water.
d) This illusion has nothing to do with the speed of light.

Solution

33) A glass beaker placed in a transparent container of olive oil can be made to disappear? Which statement best explains why?

a) The olive oil completely covers the glass beaker.
b) The refractive index of glass and olive oil are very similar.
c) Olive oil does not allow light to pass through it.
d) The refractive indices of air, olive oil and glass are very similar.
Solution

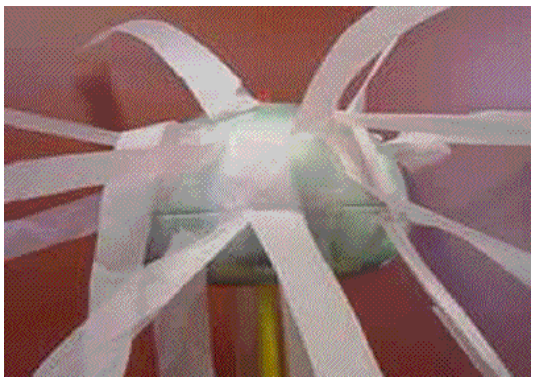
34) Light can be trapped inside glass tubes. The picture on the right shows a beam of light coming out of a glass tube. Which statement best describes why light at point "A" can not be seen but can be seen coming out on the hand of the magician.

a) This is due to a phenomenon called total external reflection.
b) Light cannot travel through glass.
c) This is due to a phenomenon called total internal reflection.
d) Light escaping from glass expands and glows with greater intensity.

Solution

35) An octopus is created from a static electricity generator and strips of tissue paper as shown below. When the magician brings his hand close to the tentacles of the octopus they move to wrap around his hand. Which term best explains why?

a) Gravity.
b) Electromotive force.
c) Attractive motor force.
d) Induced polarity.
Solution

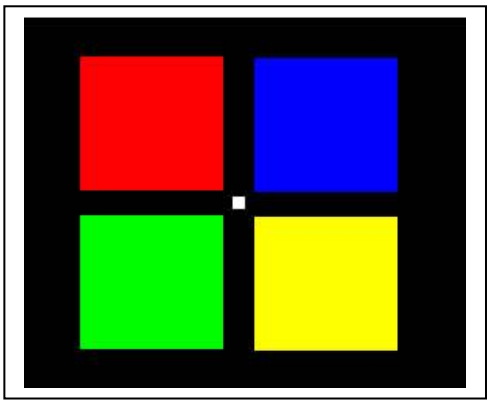


Section B

All answers must be written in the space provided.

1) Afterimages are often confused with prophetic visions.
   a) What is neural adaptation?
      Solution

   b) Explain the relationship between neural adaptation and an afterimage using complementary colours as an example.
      Solution



   c) Give an example of neural adaptation other than visual and indicate in what situation this may occur..
      Solution

2 + 2 + 2 = 6marks

2) Draw two connected nerve cells. Clearly label the following, one mark for each will be awarded.

cell body, nucleus, dendrites, axon, axon endings, myelin, synapse, neurotransmitter, receptor, direction of signal.

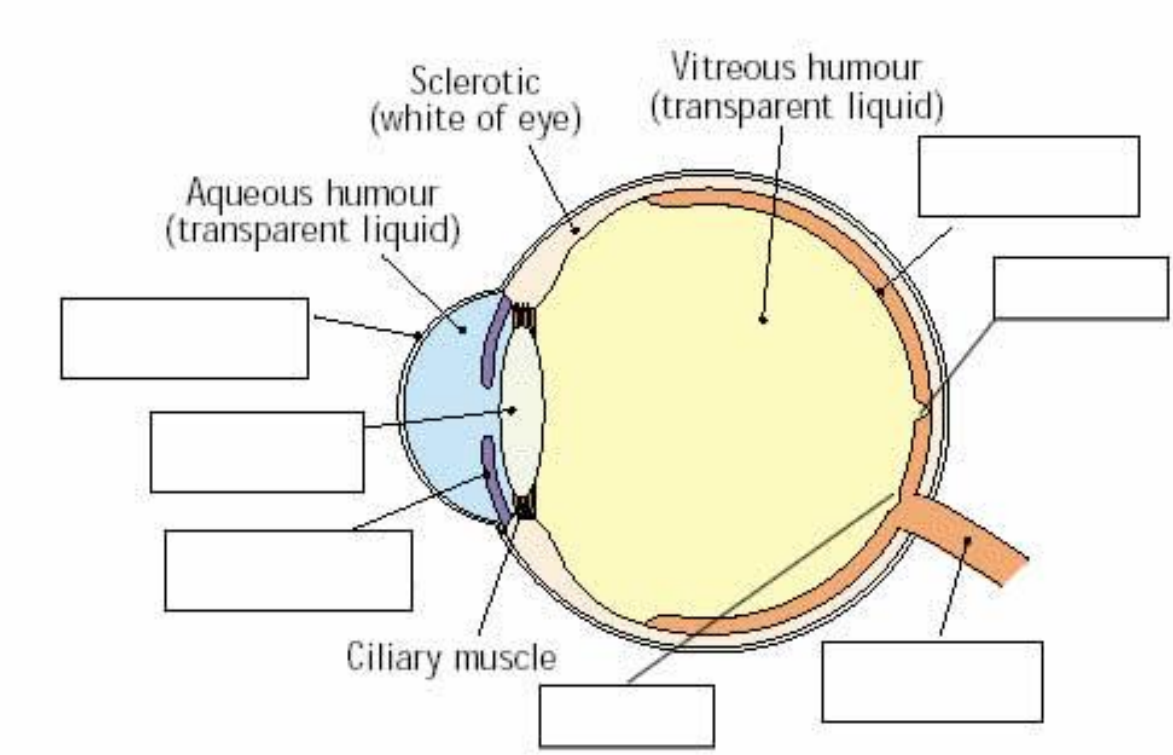
Solution

10 marks

Total of 16 marks for this page

3) The hand can sometimes be quicker than the eye. The eye is the sense organ that is responsible for vision. It is this organ that magicians try to confuse and manipulate its weaknesses. Below is a diagram of the eye

a) Label the following on the diagram
lens, fovea, blind spots, optic nerve, iris, cornea and *retina*



Solution

7 marks

During a performance, conducted at low light, the audience are temporarily blinded by a flash of bright light that conceals a crucial part of the act.
i) Which part of the eye is responsible for this temporary blindness.
Solution

b)
ii) Explain.

1+1=2 marks

c) Describe the function of the following.
i) Ciliary muscle

Solution
ii) Vitreous humour

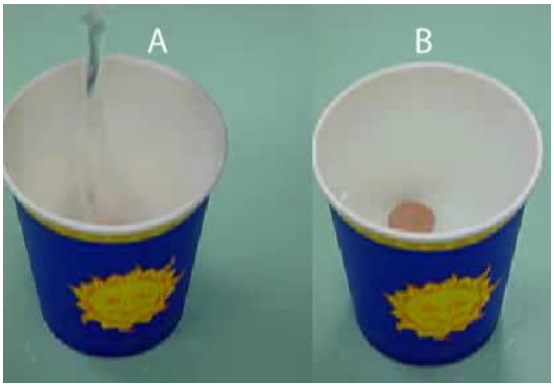
Solution
iii) Rod cells

Solution
iv) Cone cells

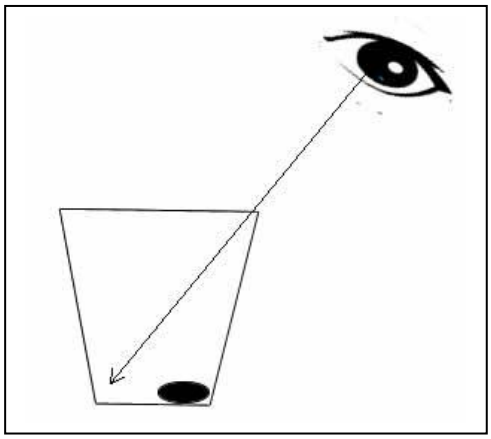
1+1+1+1=4 marks

Total of 13 marks for this page

4) A coin is placed at the bottom of a cup. The coin cannot be seen by an observer as shown by figure A. When water is poured in the cup the coin magically appears.
Solution

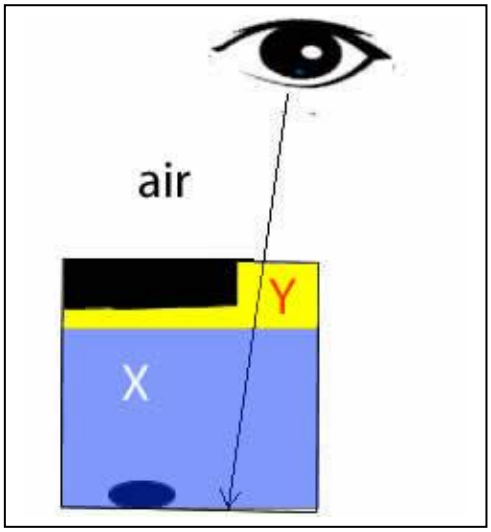


a) Use the diagram and the space below to explain how the coin becomes visible when water is added. Indicate on the diagram how the line of sight of the observer changes with water.



2 marks

b) A coin is hidden under a black brick as shown on the diagram on the right. The coin is immersed in liquid X with a layer of liquid Y floating on top. The refractive index of air is 1.00 while the refractive index of liquid Y is 1.20 and of liquid X is 1.10.
Explain if the coin will be visible to the observer by drawing the ray of light as it passes from air through the two liquids.
Solution



2 marks

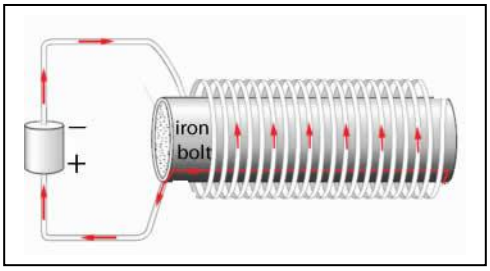
c) Water has a refractive index of 1.33. What does this mean?
Solution

1 mark

Total of 5 marks for this page

5) Electromagnets are great tools for magicians. They can be turned on or off at will. An electromagnet can be constructed by wrapping coils of wire around an iron bolt. A levitation trick demanded a strong magnet. The relationship between the number of coils of wire wrapped around the iron bolt and the strength of the magnet was tested by measuring how many paper clips were picked up. Below are the results.

Coils of wire	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Average
5	20	21	21	20	20	
10	41	39	38	40	41	
15	58	17	60	61	59	
20	78	80	79	81	82	
25	98	100	100	102	21	
30	122	120	121	125	122	
50	21	208	204	198	16	
80	324	330	318	320	325	



a) Complete the table by calculating the average number of paper clips picked up for each set of coils.

2 marks

b) Explain how you would calculate the average number of paper clips picked up with 50 coils of wire.

2 marks

c) Explain what would change from trial to trial in order to have a fair test.

2 marks

d) What is the dependent variable?

1 mark

e) What is the independent variable?

1 mark

f) Circle the correct response when comparing trial 1 to trial 2

i) The type of paper clip would :
change / stay the same

ii) The type of battery used to provide the current would :
change / stay the same/ increase as the coils increase

iii) The size of the iron bolt:
should stay the same/ can change

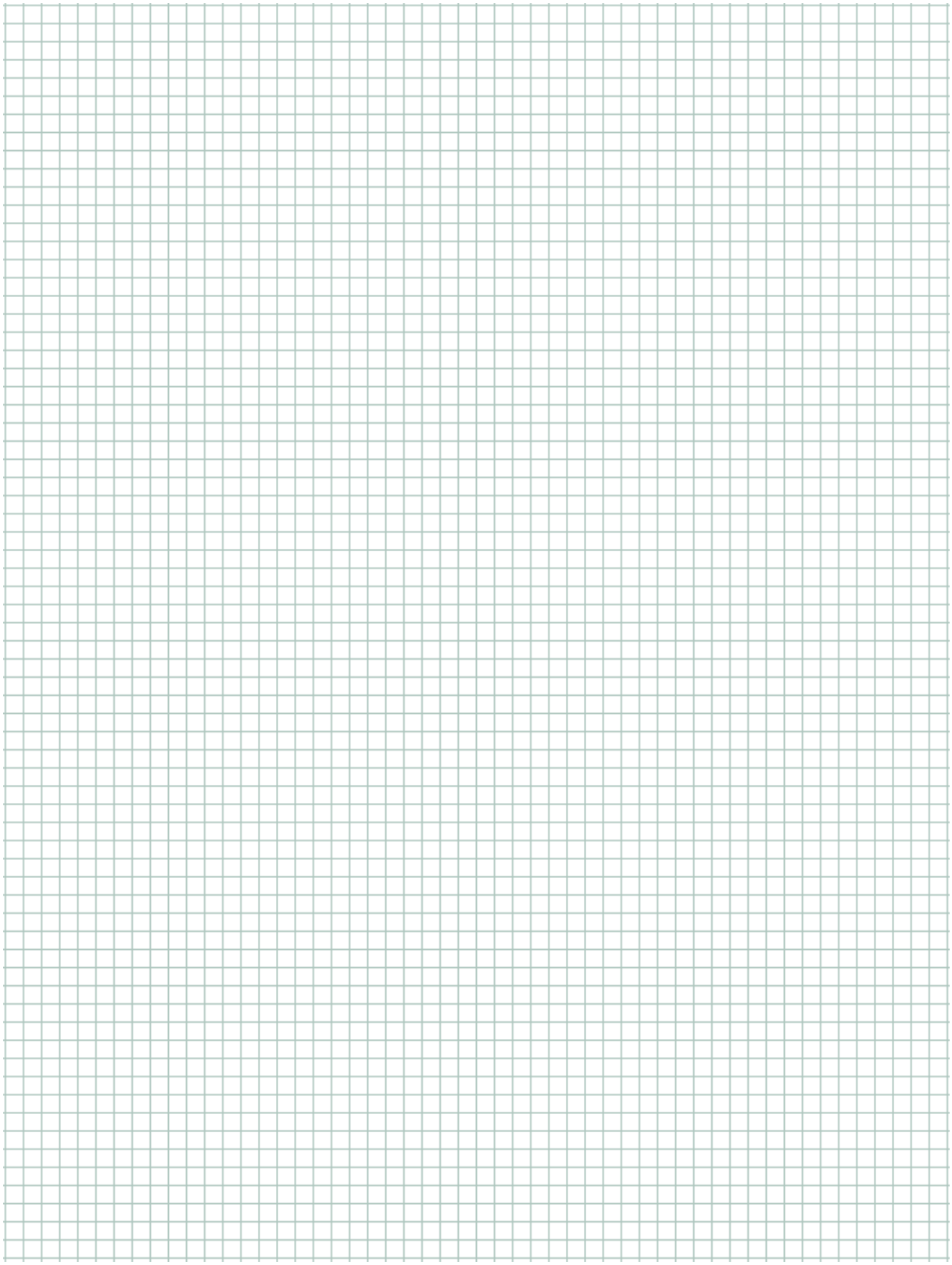
iv) The type of wire used for the coils would
get thicker / get thinner / get longer / remain unchanged

v) The number of coils would
change / remain unchanged

5 marks

Total of 13 marks for this page

g) Graph the average number of paper clips picked up against the number of coils of wire on an appropriate set of axis. Use the graph paper below and draw a line of best fit.



6 marks

Total of 6 marks for this page

h) Consider the picture on the right. It shows a levitating model of the earth. This requires electricity to work. Circle true or false to the comments below.

a. The model is held up by a permanent magnet
True / False

b. This is an example of an electrostatic force, where positive and negative charges repel each other.
True / False

c. This involves a force of repulsion
True / False

d. It is likely that the magnet in the globe and the magnet in the base both have the same pole facing each other.
True / False

e. Magnetic force is not a contact force,
For example two magnets do not have to be touching in order to exert a force on each other.
True / False

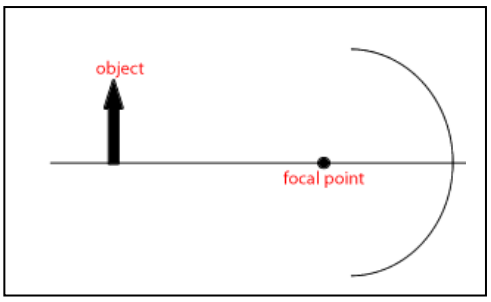
f. If a piece of paper is brought between the base and the globe the forces that keep the globe suspended weaken and the globe will fall.
True / False

g. Magnetic force always repels gravitational force and keeps the globe suspended in mid-air.
True / False

7 marks

Total of 7 marks for this page

6) Shown on the right is a picture of an object in front of a concave mirror.



a) i)Draw the rays of light originating from the object and being reflected off the mirror to form the image. Draw the rays on the image on the right.

2 marks

ii) Circle the words the relate to the image.

Diminished, magnified, upright, inverted, virtual, real

1 mark

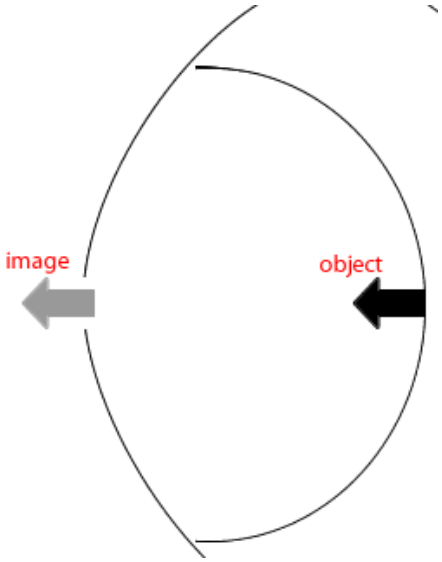
b) Two concave mirrors are placed on top of each other to create an image. An object is placed on the surface of the bottom mirror and its image appears to float above a hole in the top mirror, as shown on the right.

i) Using the diagram of the two mirrors below indicate how the rays of light are reflected off both mirrors to form the image above.

2 marks

ii) Is the image virtual or real. Explain

1 mark



Total of 6 marks for this page

7) Magicians use smoke and mirrors to create an illusion. Often it involves a flash of light and smoke which serves to confuse and distract the audience.

Aluminium foil will not burn or explode but aluminium powder will.
Aluminium reacts with oxygen in the air according to the equation below.
$4Al_{(s)} + 3O_{2(g)} \Rightarrow 2Al_2O_{3(s)}$

a) Does the equation above obey the L
Explain.

Solution

2 marks

b) Using the collision theory explain how chemical reactions take place.

Solution

2 marks

c) Why must a magician carefully prepare the aluminium in powder form if he wishes to create a sudden, quick and spectacular reaction.

Solution

2 marks

Total of 6 marks for this page

END OF EXAM