General Certificate of Education
June 2004
Advanced Subsidiary Examination

ASSESSMENT and QUALIFICATIONS ALLIANCE

GENERAL STUDIES (SPECIFICATION A) GSA2
Unit 2 Science, Mathematics and Technology

Monday 24 May 2004 Afternoon Session

In addition to this paper you will require:
- an objective test answer sheet;
- a data booklet for Questions 1 - 25 (enclosed);
- a black ball-point pen.

You may use a calculator.

Time allowed: 1 hour 15 minutes

Instructions
- Use black ball-point pen.
- Answer **both** Section 1 (Questions 1 to 25) **and** Section 2 (Questions 26 to 50) using the answer sheet provided.
- Answer **all** questions.
- For each question there are several alternative responses. When you have selected the response which you think is the best answer to a question, mark this response on your answer sheet.
- Mark all responses as instructed on your answer sheet. If you wish to change your answer to a question, follow the instructions on your answer sheet.
- Do all rough work in this book, **not** on your answer sheet.

Information
- This paper consists of **two** Sections.
  Section 1 contains 25 objective test questions (Questions 1 to 25) based on material provided in a separate data booklet.
  Section 2 contains 25 objective test questions (Questions 26 to 50) testing mathematical reasoning and its application.
- Each question carries 1 mark. No deductions will be made for wrong answers.
- 2 mm graph paper is available from the Invigilator.

Advice
- Do not spend too long on any question. If you have time at the end, go back and answer any question you missed out.

SECTION 1

Answer Questions 1 to 25

Each of the 25 questions carries 1 mark

Read the passage entitled **BATTERIES TODAY** which is printed in the separate data booklet.

Each of Questions **1** to **23** consists of a question or an incomplete statement followed by four suggested answers or completions. You are to select the most appropriate answer (**A** to **D**) in each case.

1 A battery is an example of which type of reaction?

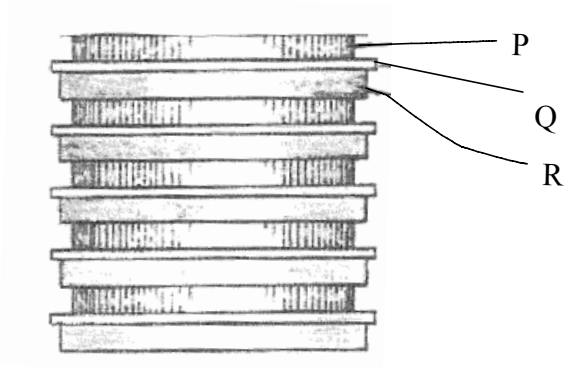
A thermo-electrical
B photo-electrical
C electro-chemical
D electro-mechanical

2 In paragraph 1 the author is suggesting that

A nowadays we like to carry appliances with us.
B mushrooms need electric heating to grow.
C battery manufacturers are making good profits.
D we like to keep batteries out of sight.

Questions 3 and 4

If you were to make a voltaic pile (paragraph 3) it might look like this.



Coins are used, separated by damp paper towel.

Silver coloured coins contain silver and copper coloured coins contain copper.

3 The best materials to use for P, Q and R in that order would be

A silver coin, distilled water on paper towel, copper coin.
B copper coin, salt solution on paper towel, copper coin.
C silver coin, salt solution on paper towel, silver coin.
D silver coin, salt solution on paper towel, copper coin.

4 A student does not follow the diagram and puts P, Q and R in a different order.

Which of the following arrangement(s) will produce a current when linked top to bottom?

1 RQPRQP
2 QRPQRP
3 PQRQRP

Answer

A if none is correct.
B if **1** alone is correct.
C if **1** and **2** only are correct.
D if all of them are correct.

5 Zinc coating (galvanising) is frequently added to iron and steel products because zinc

A is less reactive and protects the iron.
B does not react with oxygen.
C is more reactive and corrodes before the iron.
D does not conduct electricity.

6 An element which is more reactive than another will displace it in a solution. Lead is more reactive than copper and so if lead is put into copper sulphate ($CuSO_4$) the lead displaces the copper. Lead sulphate is formed and metallic copper is deposited.

Both zinc and lead cause gas to be released from sulphuric acid (H_2SO_4) because

A they release the oxygen from the water.
B they are both more reactive than hydrogen.
C they react with the acid, creating heat which boils the liquid.
D carbon dioxide is always released when carbon burns.

7 The pair of metals which would produce the largest current (paragraph 3 and Figure 1) all other factors being the same, would be

A zinc and lead.
B zinc and copper.
C silver and zinc.
D silver and gold.

8 In a cell using zinc and silver you would expect (paragraph 4)

A zinc to release electrons, silver to absorb electrons.
B zinc to absorb electrons, silver to release electrons.
C both would absorb electrons.
D both would release electrons.

9 Refer to Figures 1 and 2. If in a simple cell one electrode was copper and the other was lead

1 copper would take in electrons.
2 copper would give out electrons.
3 lead would take in electrons.
4 lead would give out electrons.

Answer

A if **1** and **3** only are correct.
B if **1** and **4** only are correct.
C if **2** and **3** only are correct.
D if **2** and **4** only are correct.

10 Primary cells are so called because they

A cannot be recharged.
B are expensive.
C were the first type produced.
D have a short life.

11 The power drain on a battery from a smoke alarm would be

A continuous small current for a long time.
B higher current for a shorter time.
C very large current for a short time.
D very large current for as long as possible.

12 Which of the following is a primary cell / battery (paragraphs 5 and 6)?

A lead-acid cell
B silver oxide button cell
C nickel-cadmium battery
D lithium-ion battery

13 The zinc-carbon battery shown in Figure 3 would be least suitable for a

A personal stereo.
B TV remote control.
C mobile phone.
D torch.

14 Doubling the power drain on an alkaline manganese battery (Figure 4)

A makes little difference to the service hours.
B doubles the service hours.
C increases the service hours by a factor of 3.
D decreases the service hours by a factor of 3.

15 The ratio of the costs of electricity per kwh for silver oxide cells and zinc-carbon cells is (paragraphs 5 and 6)

A 7:5
B 14:1
C 140:1
D 1400:1

16 Which is the correct calculation to find out how much one joule costs (£) using a 'button' cell? (paragraph 6) (1 watt = 1 joule / second)

A $\frac{7000 \times 1000}{3600}$

B $\frac{7000}{1000 \times 3600}$

C $\frac{3500}{1000 \times 7000}$

D $\frac{1000}{7000 \times 3600}$

17 Which of the following is a secondary battery (paragraph 7)?

A zinc-carbon
B alkaline manganese
C lithium-ion
D voltaic pile

18 The chemical equation for one of the reactions taking place inside a car battery (paragraph 7) is

A $H_2SO_3 + Pb = H_2O + PbSO_2$
B $H_2O + PbO = H_2O_2 + PbS$
C $H_2SO_4 + PbO = H_2O + PbSO_4$
D $H_2SO_4 + Pb = H_2O + PbSO_3$

19 Look at paragraphs 7 and 9. If the battery in a submarine is a lead-acid one, roughly how many amp hours should it be able to store?

(1 tonne = 1000 kg)

A 2.7×10^3
B 9.0×10^3
C 2.2×10^7
D 9.0×10^7

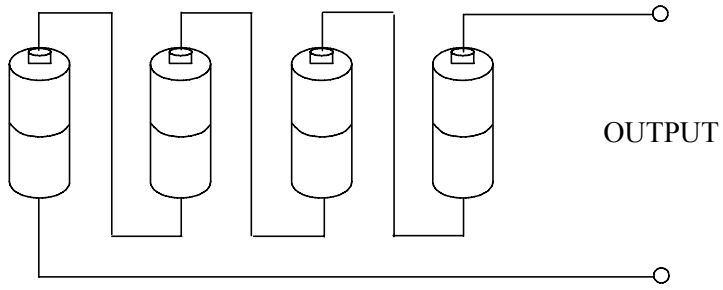
20 Which of the following statements are true descriptions of the advantages of rechargeable nickel-cadmium batteries over lead-acid batteries (paragraph 8)?

1 They work better at low temperatures.
2 They have a slower discharge.
3 They last longer.
4 They are cheaper.

Answer

A if all of them are correct.
B if **1**, **2**, and **3** only are correct.
C if **1** and **3** only are correct.
D if **2** and **4** only are correct.

21 Four nickel-cadmium batteries are connected together as shown.



If cells are linked in series and each has internal resistance r, then the total internal resistance R, will equal

A the sum of the individual resistances ($R = r_1 + r_2 \ldots$)

B the product of the individual resistances ($R = r_1 \times r_2 \ldots$)

C the reciprocal of the sum of the reciprocals ($\frac{1}{R} = \frac{1}{r_1} + \frac{1}{r_2} \ldots$)

D none of these.

22 A glossary defines the **capacity** of a battery as "the total number of amp-hours (Ah) or watt-hours (Wh) that can be withdrawn from it under specified condition".

The correct statement concerning these two quantities is

A	Ah = current × time	Wh = current ÷ time
B	Ah = power × time	Wh = power ÷ time
C	Ah = current × time	Wh = power × time
D	Ah = current ÷ time	Wh = power ÷ time

23 Which of the following statements about the development of battery-powered vehicles is true?

1 Lead-acid batteries are still the most practical.
2 There are problems in achieving a sufficiently high power : weight ratio.
3 Cheap fossil fuel is still available for combustion engines.
4 Storage of electrical power for longer journeys remains an unsolved problem.

Answer

A if **1** and **3** only are correct.
B if **2** and **4** only are correct.
C if **1**, **2** and **3** only are correct.
D if all of them are correct.

Questions 24 and 25

For Questions **24** to **25** you are given an assertion followed by a reason. Consider the assertion and decide whether, on its own, it is a true statement. Consider the reason and decide if it is a true statement. If, and only if, you decide that both the assertion and the reason are true, consider whether the reason is a valid or true explanation of the assertion. Choose your answer (**A** to **D**) as follows and indicate your choice on the answer sheet.

	Assertion	**Reason**	**Argument**
A	True	True	Reason is **a correct** explanation of assertion
B	True	True	Reason is **not a correct** explanation of assertion
C	True	False	Not applicable
D	False	True	Not applicable

	ASSERTION		**REASON**
24	The existence of 'animal electricity' was confirmed by Volta	because	he was an expert in the field of electricity.
25	Nickel-cadmium batteries are called secondary	because	they can discharge faster than lead-acid batteries.

TURN OVER FOR SECTION 2

NO QUESTIONS APPEAR ON THIS PAGE

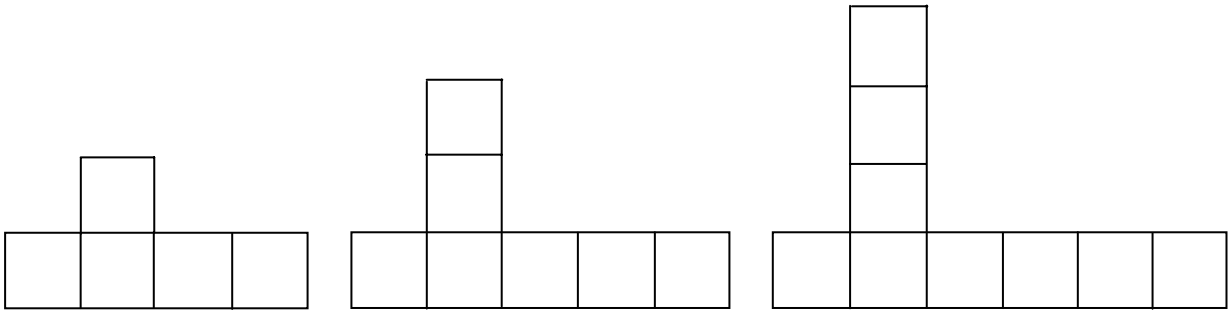
SECTION 2

Answer Questions 26 to 50

Each of the 25 questions carries 1 mark.

For each of Questions **26** to **50** choose the answer you consider the best of the alternatives offered in **A, B, C** and **D**. You are reminded that graph paper is available on request from the Invigilator.

26



Pattern 1 Pattern 2 Pattern 3

The table shows the number of matchsticks needed to make each of these three patterns.

Pattern	1	2	3
Number of matchsticks	16	22	28

If this sequence were continued the number of matchsticks needed in Pattern 50 would be

A 310.
B 316.
C 806.
D 816.

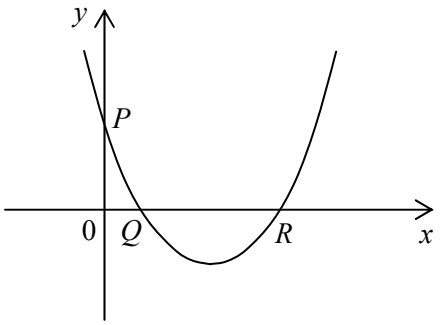
27 An astronomy book states that there are about one thousand million galaxies in the universe and that each galaxy contains about one hundred thousand million stars. If these statements are true what is the approximate number of stars in the universe?

A 10^{17}
B 10^{19}
C 10^{20}
D 10^{23}

28 Which one of the following statements can be deduced from the statement "No cat has six legs"?

A If an animal has six legs, it is not a cat.
B No animal has six legs.
C Cats have four legs.
D If an animal does not have four legs, it is not a cat.

Questions 29 and 30



Not to scale

The diagram above shows the graph of

$$y = (x - 2)(x - 5)$$

which crosses the y-axis at P and the x-axis at Q and R.

29 The coordinates of P are

A (0, 10)
B (10, 0)
C (0, 5)
D (2, 0)

30 The length of the straight line QR is

A 10 units.
B 5 units.
C 3 units.
D 2 units.

31 A vehicle has a fuel consumption of 13 km/litre. Taking 1 mile as 1.6 kilometres, and 1 litre as 0.22 gallons, what is the vehicle's approximate fuel consumption in miles per gallon?

A 1.8
B 4.6
C 37
D 95

Questions 32 and 33

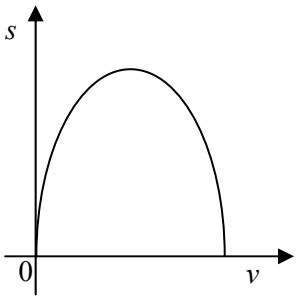
A mathematical model for the stopping distance s metres for a car travelling at v kilometres per hour is $s = \dfrac{v^2 + 100v}{250}$.

32 According to this model the stopping distance for a car travelling at 100 kilometres per hour is approximately

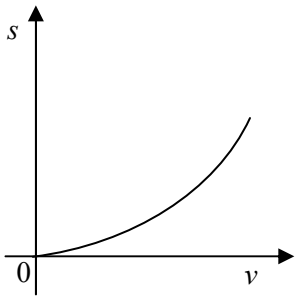
A 40 metres.
B 44 metres.
C 80 metres.
D 104 metres.

33 The graph of s against v is

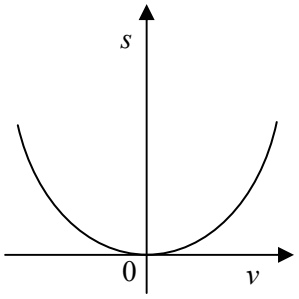
A



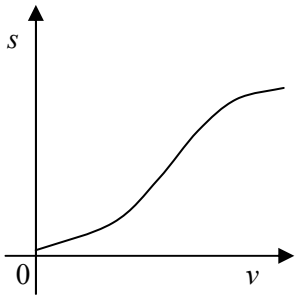
B



C



D



34 There are x hens and y sheep in a field.

The total number of animals is 36.
The total number of legs that the hens and sheep have is 114.

Which pair of equations correctly represents this information?

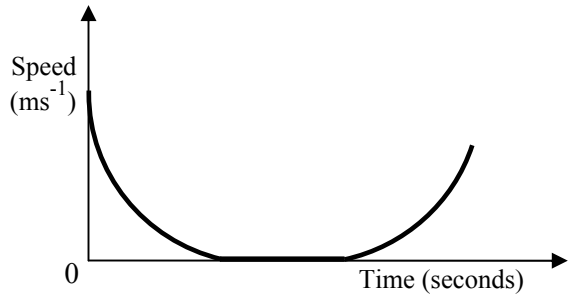
A $2x + 4y = 36$
$x + y = 114$

B $x + y = 36$
$x + 2y = 57$

C $x + y = 36$
$4x + 2y = 114$

D $xy = 36$
$2x + 4y = 114$

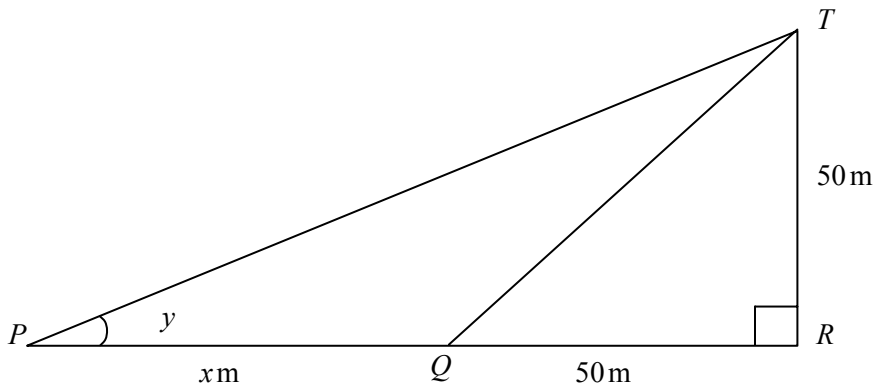
35 Part of the journey of a cyclist travelling along a hilly road is shown by the speed-time graph below.



Which one of the following is a possible description of this part of the cyclist's journey?

A The cyclist travels downhill at first, then along a level road, then uphill.
B The cyclist travels uphill at first, then along a level road, then downhill.
C The cyclist travels downhill at first, then stops for a while, then travels uphill.
D The cyclist travels uphill at first, then stops for a while, then travels downhill.

36



Which of the following is a relationship between x and y?

A $\tan y = \dfrac{x + 50}{50}$

B $\tan y = 1 + \dfrac{50}{x}$

C $\tan y = \dfrac{50}{x + 50}$

D $\tan y = 45 + \dfrac{50}{x}$

37 Given that $47^2 = 2209$, which algebraic result most easily allows you to state the value of 46×48?

A $(x - 1)^2 = x^2 - 2x + 1$

B $(x + 1)^2 = x^2 + 2x + 1$

C $x(x + 2) = x^2 + 2x$

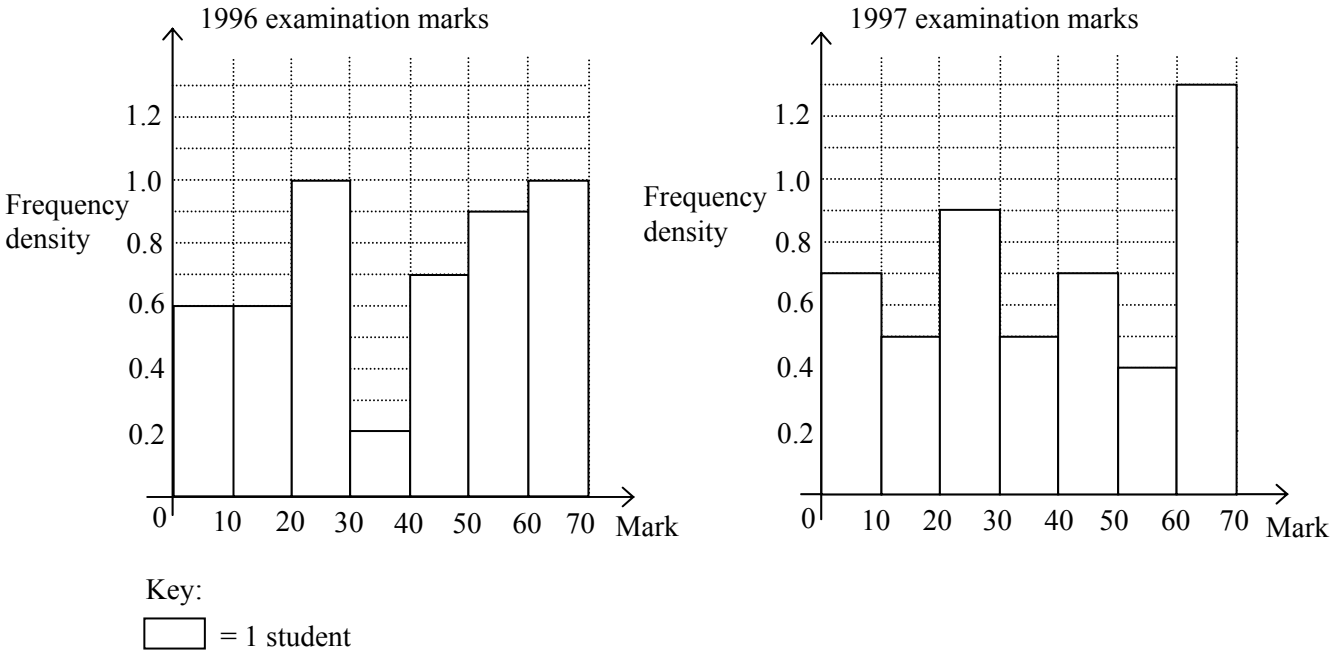
D $(x - 1)(x + 1) = x^2 - 1$

38 A group of 16 students had an average score of 58.5 in an examination. It was then discovered that one student's score had been recorded as 36 when it should have been 63. What is the correct average score?

A 58.75
B 60.19
C 60.75
D 62.44

Questions 39 and 40

In 1996 and 1997 a mathematics examination was marked out of 70. The results for a set of students from 1996 are to be compared with the results for a set from 1997. The histograms show the two sets of results to be compared.

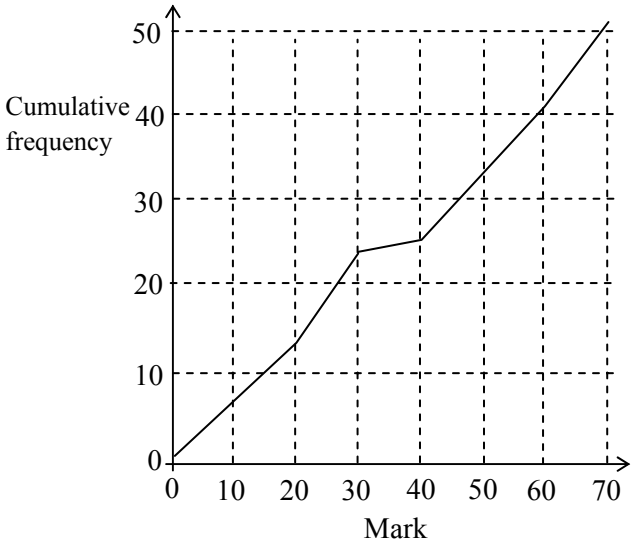


39 The number of students scoring between 40 and 50 marks in each year was

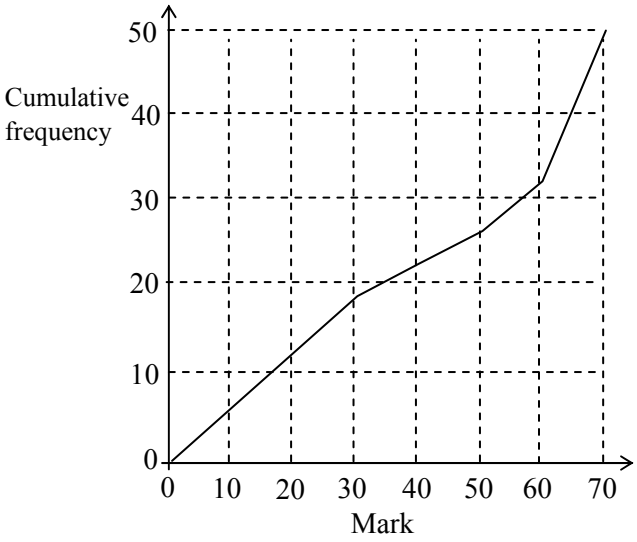
A 0.7
B 7
C 70
D unable to be found from the information.

40 A cumulative frequency diagram for the 1997 data would be

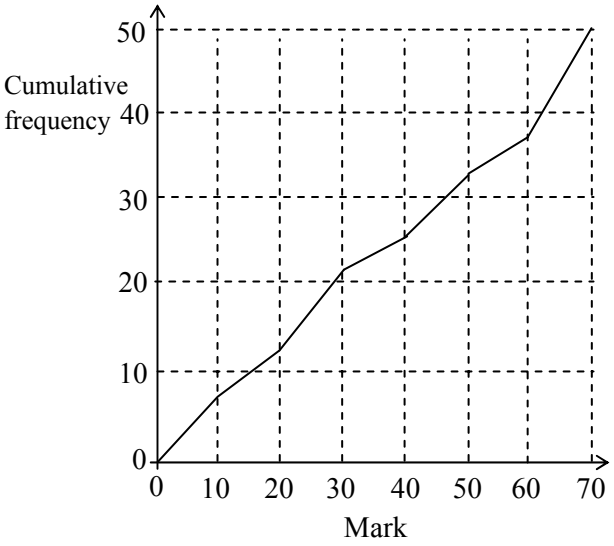
A



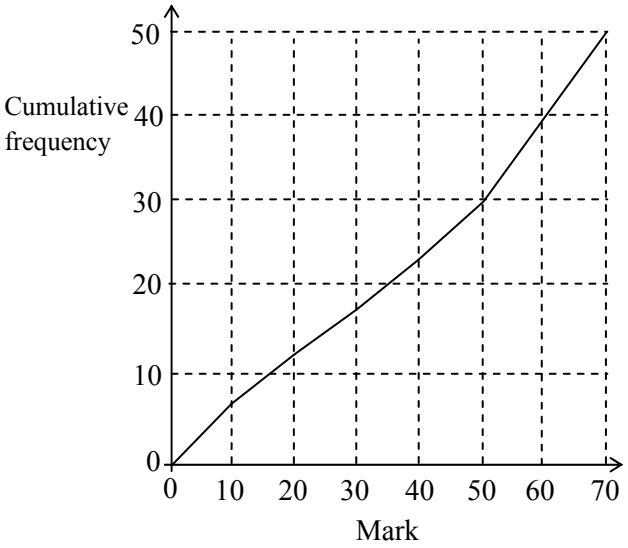
B



C



D

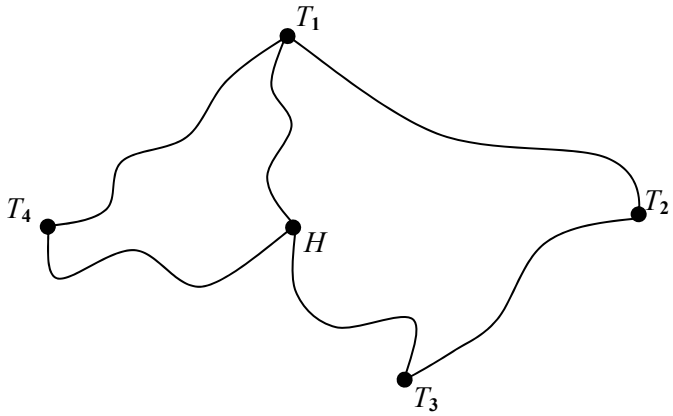


41 A solid metal sphere of radius 6 cm is melted down and made into cubes of side 1.3 cm.
How many complete cubes can be made?

[Volume of sphere of radius r, $V = \frac{4}{3}\pi r^3$]

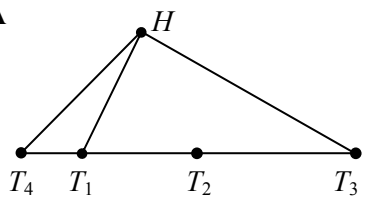
A 4
B 5
C 411
D 695

42 A driver travels between home, H, and towns T_1, T_2, T_3 and T_4 which are linked by the roads as shown in the diagram below.

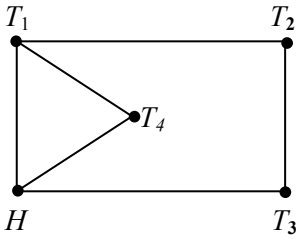


Which of the following networks cannot be used as a representation of the road links?

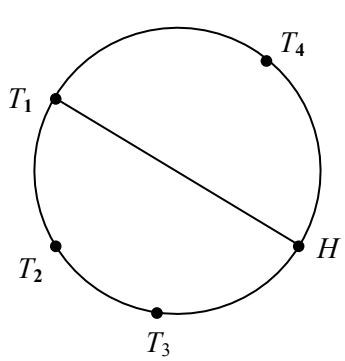
A



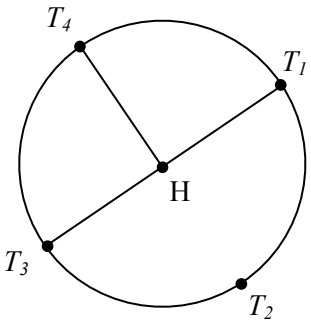
B



C



D



43 A manufacturer has two machines, the 'King' and the 'Queen', which make boxes.
On one day the 'King' made 240 boxes, of which 5% were faulty.
Overall 8% of the boxes made that day were faulty.
On that day the 'Queen' made 360 boxes.

What percentage of these were faulty?

A 3%
B 10%
C 13%
D 16%

44 A group of 180 people were tested to see how well they could estimate a minute. Each person was asked to indicate when they thought a minute elapsed after a given signal. Their results are given below.

Time (seconds)	< 45	45-50	50-55	55-60	60-65	65-70	70-75	> 75
Frequency	5	9	27	61	51	19	6	2

What is the range of the results?

A 20 seconds
B 30 seconds
C 59 seconds
D Cannot be found from this table.

45 $x^2 - 3x - 10$ is equivalent to

A $(x - 5)(x - 2)$
B $(x - 5)(x + 2)$
C $(x + 5)(x - 2)$
D $(x + 5)(x + 2)$

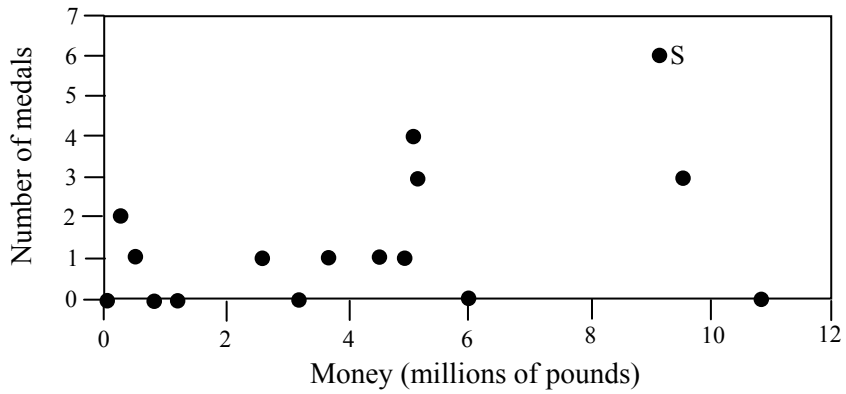
46 When $x^4 = 4^x$, which of the following statements is/are true?

(i) $x = \frac{1}{2}$ (ii) $x = 1$ (iii) $x = 4$

Answer

A if (ii) alone is true.
B if (iii) alone is true.
C if (ii) and (iii) only are true.
D if all of them are true.

47 The scatter diagram shows the amount of lottery money given to support some Olympic sports in Britain in the years 1997 – 2000 and the number of medals won in the 2000 Olympics.



Which of the following statements are supported by this data?

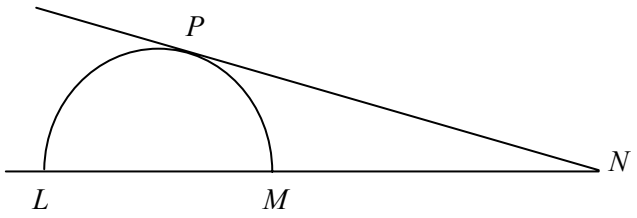
1 There is a weak positive correlation between the amount of money invested and the number of medals won.
2 The sport with greatest investment of money won the most medals.
3 The sport represented by the point S won the most medals per pound invested.
4 The modal number of medals won in these sports was zero.

Answer

A if **1** and **4** only are correct.
B if **1**, **2** and **3** only are correct.
C if **1**, **2** and **4** only are correct.
D if **1**, **3** and **4** only are correct.

48

Not to scale



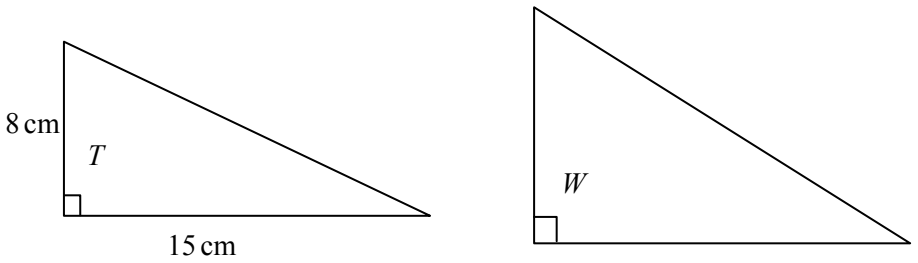
A semi-circle, with diameter $LM = 12$ cm, is drawn on the straight line LMN. A second line is drawn from N to touch the semi-circle at P. If $NP = 14$ cm, what is the length MN to the nearest centimetre?

A 3 cm
B 8 cm
C 9 cm
D 15 cm

Questions 49 and 50

A right-angled triangle, *T*, has perpendicular sides of length 8 cm and 15 cm.

A second right-angled triangle, *W*, has perpendicular sides each 2 cm longer than the corresponding sides of triangle *T*.



Not to scale

49 Consider the following statements.

1 The perimeter of *W* is 6 cm greater than the perimeter of *T*.
2 The area of *W* is 25 cm^2 greater than the area of *T*.

Answer

A if both statements are correct.
B if **1** is correct and **2** is incorrect.
C if **2** is correct and **1** is incorrect.
D if neither statement is correct.

50 Which of the following statements is correct?

A Triangle *W* is an enlargement of triangle *T*, scale factor 1.2
B Triangle *W* is an enlargement of triangle *T*, scale factor 1.25
C Triangle *W* is an enlargement of triangle *T*, scale factor 2
D Triangle *W* is not an enlargement of triangle *T*.

END OF QUESTIONS

THERE ARE NO QUESTIONS PRINTED ON THIS PAGE

General Certificate of Education
June 2004
Advanced Subsidiary Examination

GENERAL STUDIES (SPECIFICATION A) GSA2
Unit 2 Science, Mathematics and Technology

Data Booklet

Monday 24 May 2004 Afternoon Session

Data booklet for use with **Section 1 Questions 1** to **25**.

PASSAGES AND FIGURES FOR QUESTIONS 1 TO 25

Consider the following passage and Figures 1 to 5.

BATTERIES

(1) The idea of portable electrical power has mushroomed in recent years. A typical modern household will have 40 to 50 batteries hidden away in a huge range of consumer products.

(2) In 1786 Luigi Galvani, a professor of anatomy, was working on the effect of electricity from lightning on muscles and set up a device consisting of long wires connected to frogs' legs. On one occasion he noticed that the legs gave a sudden kick when he pressed the brass hook from which they were hanging against the iron grid on which his wife had prepared them for cooking. He concluded that living things had their own intrinsic electricity and he called this effect 'animal electricity'.

(3) As would be the case today, his work had to be verified and the scientist chosen was another Italian, Alessandro Volta, the Professor of Physics at Pavia University. Volta believed that the electricity came from the metals and not the animal and in 1800 he proved this to be correct. He discovered that, when different metals are connected and touch something moist, a current flows. He found that the size of the electric current depended on the different metals used. He arranged the metals in a series so that the further apart a pair of metals was in the list, the greater was the electric current. We now know this as the 'reactivity series' (see *Figure 1*). He invented a device which consisted of a stack of discs of zinc and silver separated by blotting paper soaked in salt water. He called this device the 'voltaic pile'. It was the first battery.

Volta's Series

Reactivity	Metal
Most reactive ↑	Lithium
	Carbon*
	Zinc
	Iron
	Lead
	Copper
	Silver
Least reactive	Gold

Lithium and carbon were not part of Volta's series.
*Carbon is a non-metal but is a good conductor of electricity.
They have been added for comparison.

Figure 1

(4) Strictly, each separate pair of metal plates should be called a 'cell'. A collection of cells is called a 'battery' (this came from the term used by the army for a line of guns). In everyday language the word 'battery' is used when it would be more correct to use the term 'cell'. In all cells the flow of electric current results from chemical reactions. During these chemical reactions the more reactive metal releases the electrons and the less reactive metal gains them. This results in a flow of electrons along the wire which connects the two metals. The flow of electrons is the current, which the cell provides (see *Figure 2*). Early cells were wet cells since they contained watery solutions. In modern 'dry' cells this electrolyte is a paste.

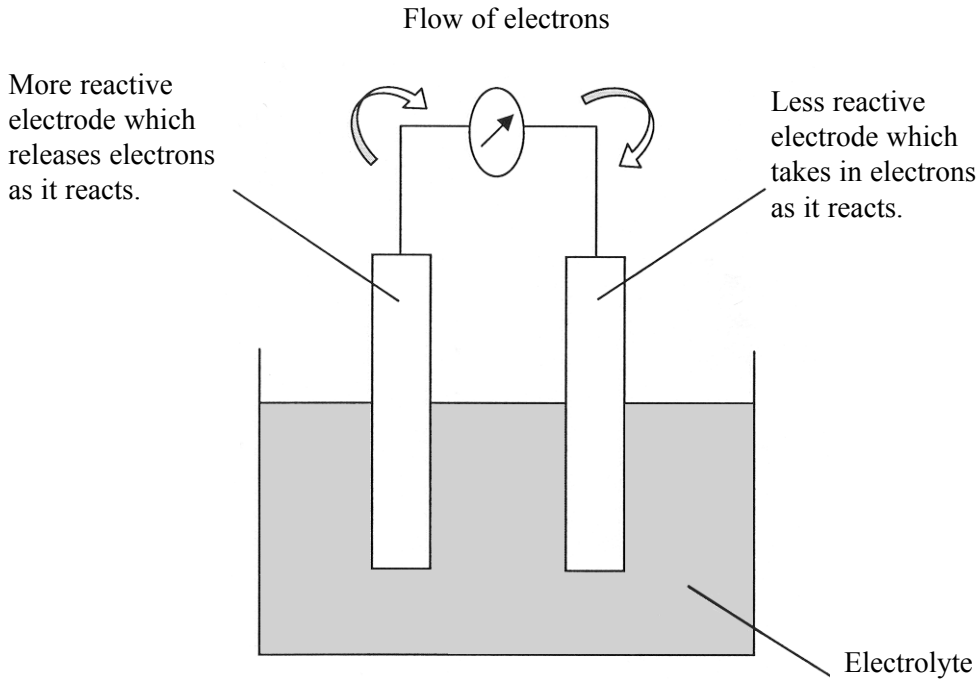


Figure 2: A Simple Cell

(5) As the two metals react, the available chemical reactants eventually run out and the battery reaches the end of its life and needs to be replaced. Batteries of this type are called 'primary cells'. The most common primary cells are zinc-carbon batteries (see *Figure 3*). Carbon, although a non-metal, is a good conductor of electricity. These batteries are suitable only for low power applications such as torches. They tend to have a short life since the zinc reacts even when no current is taken from the cell. They are also liable to leak when old. They are used for convenience rather than efficiency, as they cost about £50 per kilowatt-hour of energy compared with 5 pence per kilowatt-hour for mains electricity.

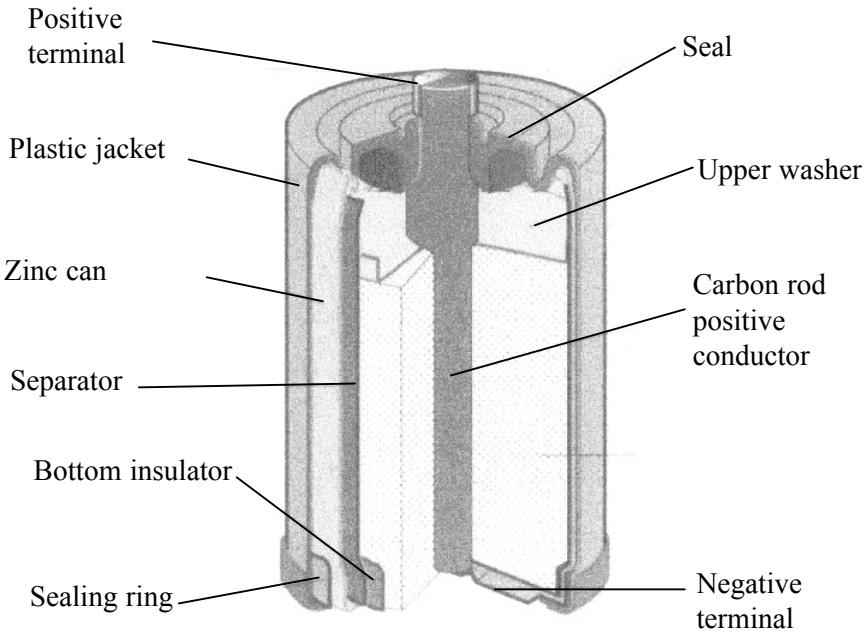


Figure 3: A Zinc-Carbon Battery

(6) Longer life primary cells are alkaline manganese batteries; they are particularly useful for high power applications, such as portable CD players. They have many advantages over zinc-carbon cells, including higher energy output, longer shelf life, better leakage resistance and superior low temperature performance. In comparison to the zinc-carbon cell, the alkaline cell delivers up to ten times the ampere-hour capacity at high and continuous power drain conditions (*Figure 4*). Primary cells can also come in the form of silver oxide 'button cells' used in watches and calculators. These are convenient for low powered instruments but they may cost as much as £7 000 for one kilowatt-hour of energy.

Discharge Characteristics at Various Power-Drains of a 1.5 V battery

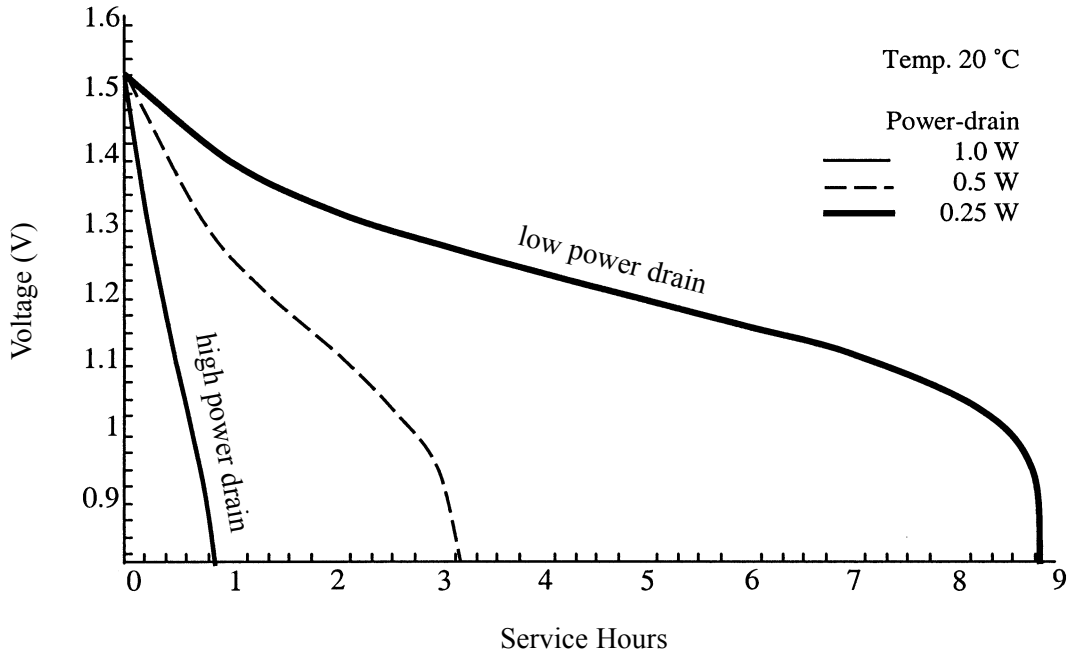


Figure 4: Discharge Characteristics for Alkaline Manganese Batteries

(7) For many applications we need rechargeable or 'secondary' batteries. The most commonly used rechargeable battery is the lead-acid cell or car battery (see *Figure 5*). When the battery is discharged, the lead on the negative plate, the lead oxide on the positive plate and sulphuric acid electrolyte are consumed forming water and lead sulphate. To charge the battery again, an electric current must be applied to the cell and the original reactants are reformed. Over the years many improvements have been made to these batteries and they exist in many different forms. There is the 'pasted plate' design, where the active material (lead oxide) is pasted onto a lead grid current collector. These are used as car batteries, originally known as starting, lighting and ignition batteries. A modified version of this design is known as the 'leisure battery' used on caravans and boats. Finally there is the 'traction battery' used in milk floats and fork-lift trucks where the active material (lead oxide) is contained in polyester tubes, with the lead current collector as a spine in the centre of each tube. Some of the biggest batteries of this type are found in submarines and weigh up to 250 tonnes.

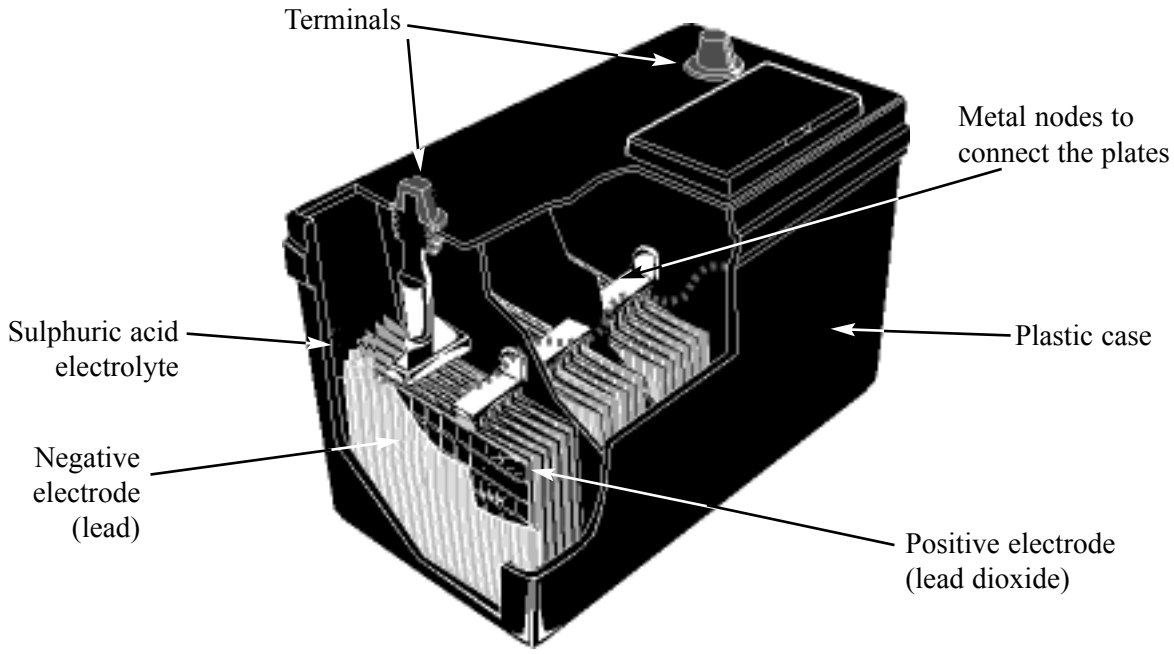


Figure 5: A Car Battery

(8) Rechargeable nickel-cadmium batteries were invented at the end of the nineteenth century. These are now widely available. They have several advantages over lead-acid such as faster discharge, better low temperature performance and long operation life (about 1 000 cycles), but there are some disadvantages such as expense and environmental concerns over disposal.

(9) With the advent of the electronics industry there has been a drive to produce more efficient rechargeable batteries to allow devices to become more portable. Lithium is the lightest of all metals and has a high reactivity. It is therefore an obvious candidate for battery use. Theoretically a lithium battery can store 300 amp hours per kilogram, compared with 90 amp hours per kilogram for a lead acid cell (One amp hour refers to a battery supplying 1 amp for 1 hour). Lithium's high reactivity, however, makes it difficult to work with. It reacts easily with oxygen in the air causing oxide films to form, which insulate the lithium from the electrolyte. The problem has been overcome by developing the idea of the insertion electrode. This removes the need to use any free lithium metal. Two kinds of electrodes are used: one made from a metal compound such as manganese dioxide and the other made of carbon, often graphite. When the cell discharges, lithium ions from the electrolyte insert into the manganese dioxide, while at the other electrode a lithium ion is extracted from the carbon matrix. The electrode is polymer based, rather than an aqueous solution.

(10) Lithium-ion batteries generate approximately 4 V, which is 3 times as much as a zinc-carbon battery and they are more environmentally friendly than 'heavy metal' batteries. They are used extensively in laptops and mobile phones. The Sony Corporation first mass-produced lithium cells in the early 1990s. In 1997 alone it is estimated that 190 million cells were manufactured in Japan with a value of US$2 000m.

(11) The use of batteries to power cars has great benefits in terms of pollution. The world's first production line electric car, the General Motors EV1, still uses a lead-acid battery. The mass of the battery is about 540 kg. This mass of oil-based fuel would power the car for thousands of kilometres, while the battery has a range of about 110 kilometres between recharges.

(12) Clearly battery technology is still in its infancy and substantial improvements are likely over the next few years.

END OF PASSAGE

THERE ARE NO DATA PRINTED ON THIS PAGE

THERE ARE NO DATA PRINTED ON THIS PAGE

THERE ARE NO DATA PRINTED ON THIS PAGE