

Energy 4

Name: _____

Class: _____

Date: _____

Time: **70 minutes**

Marks: **64 marks**

Comments:

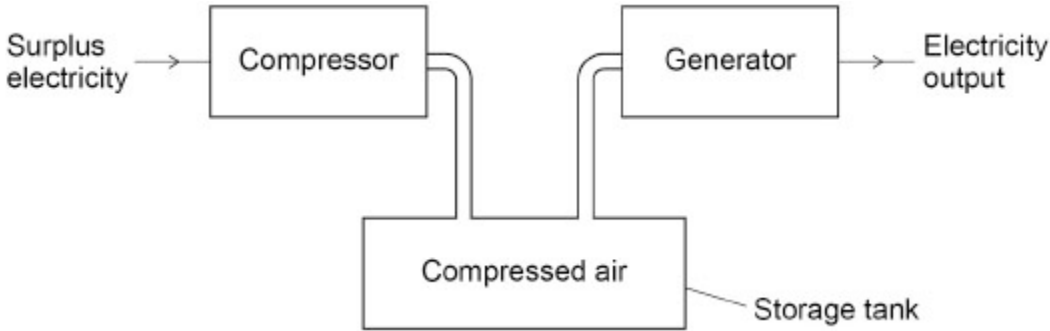
1.

Energy can be stored using a Compressed Air Energy Storage (CAES) system.

When more electricity is generated than is needed, a CAES system uses the surplus electricity to compress air in a storage tank.

When there is a greater demand for electricity, the CAES system releases the compressed air to generate electricity.

The figure below shows a diagram of the CAES system.



- (a) The CAES system has two processes:
 - compressing air to store energy. This process has an efficiency of 0.72
 - releasing the air to generate electricity. This process has an efficiency of 0.86

Calculate the efficiency of the CAES system.

Give your answer to 2 significant figures.

Efficiency of the CAES system (2 significant figures) = _____

(3)

The generator works when forces from the compressed air cause a turbine to rotate.

When particles of air collide with the turbine they transfer energy to the turbine.

In warm weather the temperature of the compressed air increases, increasing the pressure inside the storage tank.

- (b) Explain how the motion of the particles in warmer air causes an increase in the power transferred to the turbine.

(4)

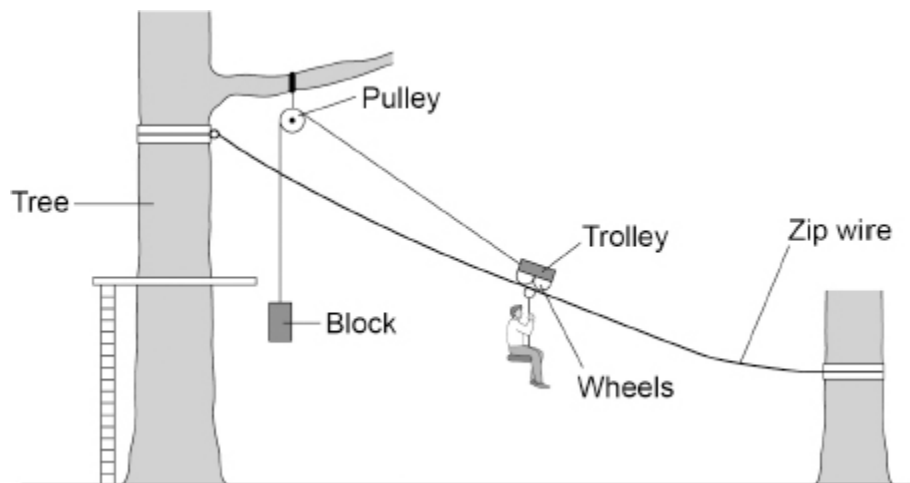
- (d) The UK government wants the amount of carbon dioxide released into the atmosphere to be reduced.

Explain why efficient energy storage is important in reducing the amount of carbon dioxide released when generating electricity.

(4)
(Total 17 marks)

2.

The figure below shows a person using a zip wire to move from a tree to the ground.



As the person moves down the zip wire, the block moves upwards.

- (a) What happens to the gravitational potential energy of the person as the person accelerates down the zip wire?

Tick (✓) **one** box.

Decreases

Stays the same

Increases

(1)

- (b) What happens to the kinetic energy of the person as the person accelerates down the zip wire?

Tick (✓) **one** box.

Decreases

Stays the same

Increases

(1)

(c) The block is 3.4 m above the ground when the person is at the bottom of the zip wire.

mass of block = 2.5 kg

gravitational field strength = 9.8 N/kg

Calculate the gravitational potential energy of the block.

Use the equation:

gravitational potential energy = mass × gravitational field strength × height

Gravitational potential energy = _____ J

(2)

The trolley is a seat suspended from wheels which can roll along the zip wire.

(d) When the person reaches the end of the zip wire, the person gets off the trolley.

The block falls downwards pulling the trolley back to the top of the zip wire.

maximum speed of block = 4.8 m/s

mass of block = 2.5 kg

Calculate the maximum kinetic energy of the block.

Use the equation:

kinetic energy = 0.5 × mass × (speed)²

Maximum kinetic energy = _____ J

(2)

(e) As the trolley moves, work is done against friction.

What is the effect of this?

Tick (✓) **one** box.

Some energy is destroyed.

Some energy is transferred to the surroundings.

The total energy of the block and trolley increases.

(1)

(f) The person oils the wheels on the trolley.

Explain how this will affect the speed of the person down the zip wire.

(2)

(Total 9 marks)

3.

Wind power and solar power are both renewable energy resources used to generate electricity for the National Grid.

(a) Which of the following is also a renewable energy resource?

Tick (✓) **one** box.

Geothermal

Natural gas

Nuclear fuel

(1)

(b) The energy transferred by the National Grid in one second was 36 gigajoules (GJ).

Which of the following is the same as 36 gigajoules?

Tick (✓) **one** box.

$36 \times 10^3 \text{ J}$

$36 \times 10^6 \text{ J}$

$36 \times 10^9 \text{ J}$

$36 \times 10^{12} \text{ J}$

(1)

(c) **Figure 1** shows how the mean power output from solar and wind energy resources in the UK varied between 2014 and 2019.

Figure 1

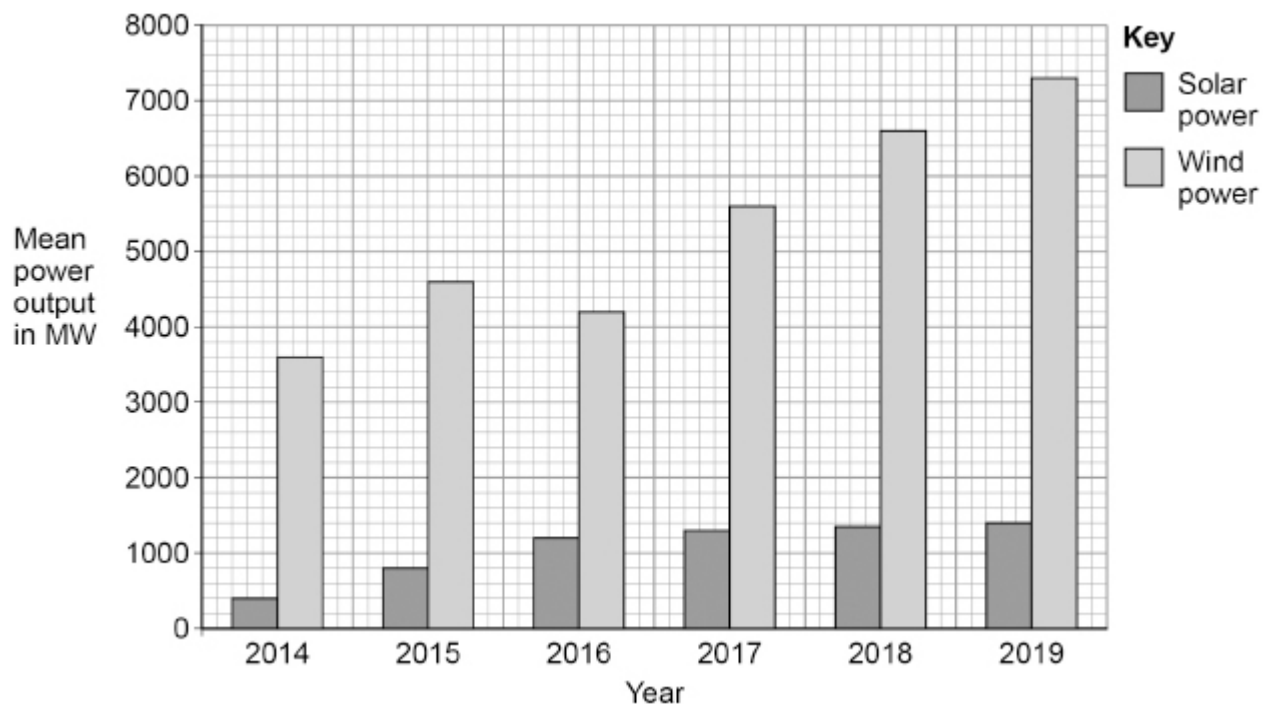


Figure 2 shows how the power output from solar and wind energy resources varies in a typical year.

4.

Figure 1 shows a child's toy.

A child pushes down on the toy to compress the spring. The spring then launches the toy into the air.

Figure 1



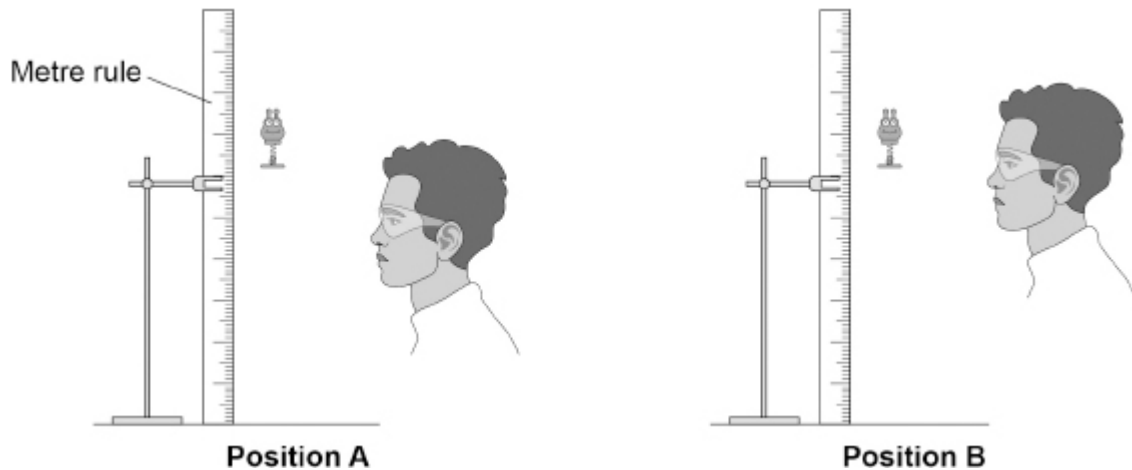
(a) A student measured the maximum height reached by the toy.

The student placed a vertical metre rule near the toy, and observed the height reached by the toy.

The student repeated the experiment, observing from a different position.

Figure 2 shows the toy at its maximum height and the two positions of the student.

Figure 2



(c) When the spring launches the toy into the air, the temperature of the air increases.

Explain why the child's toy on its own is **not** a closed system.

(2)
(Total 9 marks)

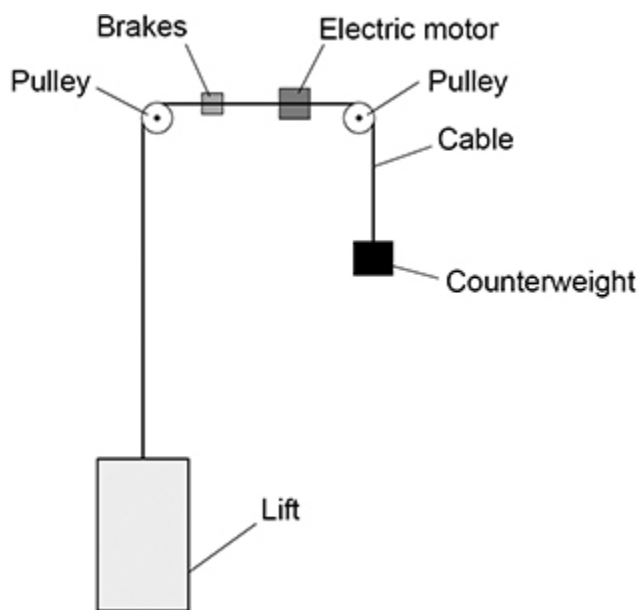
5.

The diagram below shows a lift near the bottom of a building.

The lift is attached by a cable to a counterweight.

An electric motor moves the lift.

The lift is moving up.



(a) As the lift moves up, how far does the counterweight move down?

Tick (✓) **one** box.

A shorter distance than the lift.

The same distance as the lift.

A longer distance than the lift.

(1)

(b) What happens to the gravitational potential energy of the counterweight as it moves down?

Tick (✓) **one** box.

It decreases

It stays the same

It increases

(1)

(c) Calculate the change in gravitational potential energy of the lift when it moves up 4.0 m

The mass of the lift is 1300 kg

gravitational field strength = 9.8 N/kg

Use the equation:

gravitational potential energy = mass × gravitational field strength × height

Change in gravitational potential energy = _____ J

(2)

(d) Complete the sentences.

Choose answers from the box.

chemical	elastic potential	gravitational potential
internal	kinetic	

Friction between the brakes and the cable causes the speed of the lift to decrease.

As the speed decreases, there is a decrease in the _____
energy of the lift.

As the speed decreases, there is an increase in the _____
energy of the brakes.

(2)

(e) The motor transfers different amounts of energy each time people use the lift.

Which factors affect the amount of energy transferred by the motor as the lift moves?

Tick (✓) **two** boxes.

- The distance moved by the lift
- The height of the building
- The length of the steel cable
- The maximum power of the motor
- The weight of the people in the lift

(2)

(f) The weight of the lift and the counterweight stretch the cable by 0.015 m

The cable acts like a spring with a spring constant of 880 000 N/m

Calculate the elastic potential energy of the stretched cable.

Use the equation:

$$\text{elastic potential energy} = 0.5 \times \text{spring constant} \times (\text{extension})^2$$

Elastic potential energy = _____ J

(2)

(g) A lift system using a counterweight is more efficient than a lift system that does not use a counterweight.

How does having a more efficient system affect the energy transferred by the motor?

Tick (✓) **one** box.

Less energy is transferred.

The same amount of energy is transferred.

More energy is transferred.

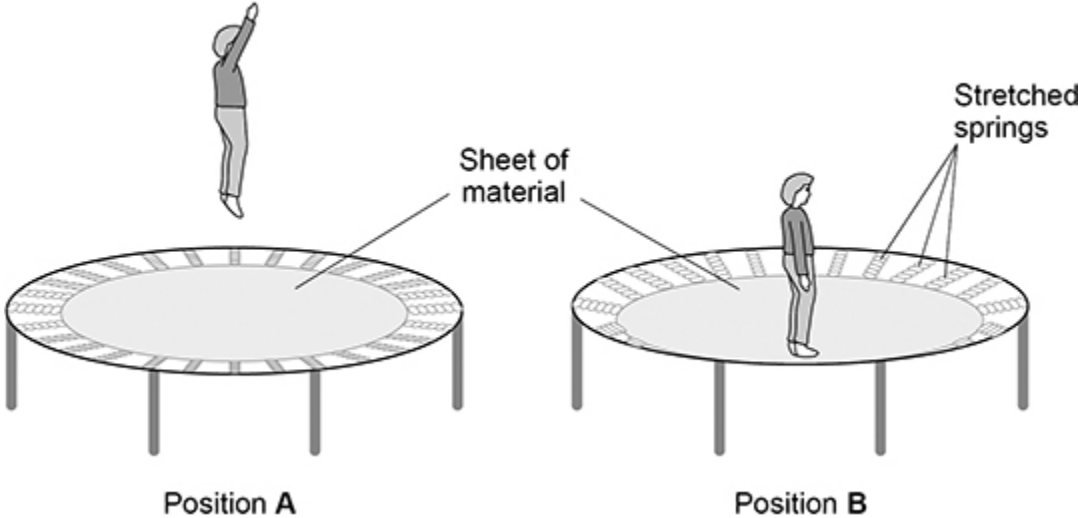
(1)

(Total 11 marks)

6.

A trampoline is made from a sheet of material held in place by stretched springs.

The figure below shows a child on a trampoline.



- (a) Position **A** shows the child's maximum height above the trampoline.
- Position **B** shows the lowest position reached by the child when landing on the trampoline.

Describe the changes to the stores of energy of the:

- child
- springs
- surroundings

as the child moves from position **A** to position **B**.

Child _____

Springs _____

Surroundings _____

(c) As the child bounces on the trampoline the child does work.

What is the work done by the child equal to?

Tick (✓) **one** box.

The average force applied by the child

The maximum force applied by the child

The total energy store of the child

The total energy transferred by the child

(1)
(Total 10 marks)

Mark schemes

1.

(a) efficiency = 0.72×0.86

1

efficiency = $0.61(92)$

1

0.62

allow use of percentages if % is seen

1

- (b) (at higher temperatures) the (average) speed of the particles is greater
allow the (average) kinetic energy of the particles is greater
*do **not** accept vibrations*

1

so the frequency of collisions (between particles and the turbine) increases

1

and the force of each collision (between a particle and the turbine) is greater

1

so more energy transferred (each second)

dependent on MP2 or MP3

ignore increases the power

1

- (c)

$$48 = \frac{\text{mass}}{5.0 \times 10^5}$$

1

$$\text{mass} = 48 \times 5.0 \times 10^5$$

1

$$\text{mass} = 24\,000\,000$$

the equation $\text{density} = \frac{\text{mass}}{\text{volume}}$ must have been used to score subsequent marks

1

$$E = 24\,000\,000 \times 1100 \times 15$$

allow a correct substitution using their calculated value for mass

1

$$E = 396\,000\,000\,000$$

allow an answer consistent with their calculated value for mass

1

$$E = 3.96 \times 10^{11}(\text{J})$$

allow a correctly converted answer consistent with their calculated value for energy using the equation $\Delta E = m c \Delta\theta$

1

- (d) (efficient energy storage means) less energy is wasted 1
- (to reduce carbon dioxide emissions) less fossil fuel used / burned
allow named fossil fuel 1
- the amount of energy generated from renewable resources will need to increase
allow named renewable resources
- or**
- (most) renewable resources do not generate electricity all the time
allow renewable resources are unreliable 1
- (so) efficient energy storage will help to meet the demand for energy / electricity 1

[17]

- 2.** (a) decreases 1
- (b) increases 1
- (c) $E_p = 2.5 \times 9.8 \times 3.4$ 1
- $E_p = 83.3 \text{ (J)}$
allow 83 (J) 1
- (d) $E_k = 0.5 \times 2.5 \times 4.8^2$ 1
- $E_k = 28.8 \text{ (J)}$
allow 29 (J) 1
- (e) some energy is transferred to the surroundings 1
- (f) speed will increase 1
- (because work done against) friction decreases 1

[9]

- 3.** (a) geothermal 1
- (b) $36 \times 10^9 \text{ J}$ 1

- (c) **Level 3:** Relevant points (reasons / causes) are identified, given in detail and logically linked to form a clear account.

5-6

Level 2: Relevant points (reasons / causes) are identified, and there are attempts at logical linking. The resulting account is not fully clear.

3-4

Level 1: Points are identified and stated simply, but their relevance is not clear and there is no attempt at logical linking.

1-2

No relevant content

0

Indicative content

Figure 1

- the power output from wind increased
- because more wind turbines were built

- the power output from solar increased
- because more solar panels were built

- power output from wind and solar may have increased due to climate change

For 2015 and 2016

- wind power was lower in 2016 than in 2015
- because 2016 was less windy than 2015

Figure 2

- for most of the year the electricity generated from wind is greater than from solar.
- the electricity generated from wind is greater in winter than in summer
- because winter is windier than summer

- the electricity generated from solar is greater in summer than in winter
- because hours of sunlight are longer in summer
- and because the intensity of sunlight is greater in summer

to access Level 3, the answer should describe trends in both graphs, and in solar power and wind power, and give some explanation for changes.

[8]

4.

- (a) the measurement will be more accurate
allow parallax error is reduced

1

because (in position B) the eye is level with (the maximum height of) the toy

1

(b) 64 cm = 0.64 m

1

$$0.049 = m \times 9.8 \times 0.64$$

allow a correct substitution using an incorrectly / not converted height

1

$$m = \frac{0.049}{9.8 \times 0.64}$$

allow a correct rearrangement using their incorrectly / not converted height

1

$$m = 0.0078125 \text{ (kg)}$$

allow an answer consistent with their incorrectly / not converted height

1

$$m = 0.0078 \text{ (kg)}$$

this mark can only be scored if the equation $E_p = m g h$ has been used

1

(c) energy from the toy is dissipated (to the surroundings / air)

allow energy from the toy is transferred to the surroundings / air

1

(but) in a closed system the total energy remains constant

1

[9]

5.

(a) the same distance as the lift

1

(b) it decreases

1

(c) $E = 1300 \times 9.8 \times 4.0$

1

$$E = 50960 \text{ (J)}$$

allow 51000 (J)

1

(d) kinetic

1

internal

1

this order only

- (e) the distance moved by the lift 1
- the weight of the people in the lift 1
- (f) $E_e = 0.5 \times 880\,000 \times 0.015^2$ 1
- $E_e = 99 \text{ (J)}$ 1
- (g) less energy is transferred 1

[11]

6.

- (a) **Child**
- gravitational potential energy decreases 1
- kinetic energy increases **and** then decreases to zero 1
- Springs**
- elastic potential energy increases
- ignore references to kinetic energy of the springs* 1
- Surroundings**
- internal / thermal store of energy increases
- allow energy is dissipated*
- allow (average) kinetic energy of the particles increases* 1
- ignore descriptions of energy transfers before the child reaches position A*
- (b) **At position A**
- $4.9 = 0.5 \times k \times 0.056^2$ 1
- $k = \frac{2 \times 4.9}{0.056^2} = 3125 \text{ (N/m)}$ 1

At position B

$$8.1 = 0.5 \times 3125 \times e^2$$

*allow a correct substitution of an incorrectly calculated value of k
using 0.056 m **and** 4.9 J*

1

$$e = \sqrt{\left(\frac{2 \times 8.1}{3125}\right)}$$

allow $e^2 = 0.005184$

*allow a correct re-arrangement using an incorrectly calculated value
of k*

1

$$e = 0.072 \text{ (m)}$$

allow an answer consistent with their calculated value of k

1

(c) the total energy transferred by the child

1

[10]