4-1 / 6-1 Energy – Physics and Trilogy

1.0 A weightlifter picks up a barbell.

1.1 Which type of energy is stored in the barbell when it is held above the weightlifter's head?

[1 mark]

Tick **one** box**.**

Chemical potential ☐

Elastic potential ☐

Gravitational potential ☐

Kinetic ☐

1.2 The weightlifter drops the barbell.

The barbell's store of which type of energy increases as the barbell falls.

[1 mark]

Tick **one** box**.**

Chemical potential ☐

Elastic potential ☐

Gravitational potential ☐

Kinetic ☐

1.3 Use the data in **Table 1** to draw a line between each calculation and the energy change it is calculating.

Draw **two** lines only.

Table 1

mass of barbell	50 kg
gravitational field strength	9.8 m/s^2
height the barbell drops	2 m
maximum speed the barbell drops	6.2 m/s

[1 mark]

Calculation	**Increase/decrease in**
	Chemical potential energy
50 × 9.8 × 2	Elastic potential energy
	Gravitational potential energy
½ × 50 × 6.2 × 6.2	Kinetic energy

1.4 The weightlifter's internal store of energy decreased when he lifted the bar.

The bar's internal store of energy increased by a smaller amount.

Explain why.

[2 marks]

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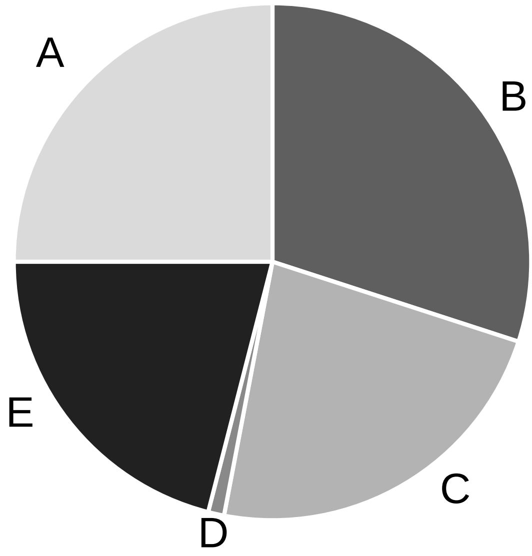
2.0 Electricity in the UK is produced from a number of energy resources.

Figure 1 below shows the proportion of each energy resource used.

The labels have been removed from the pie chart.

Figure 1



2.1 Complete the table.

[2 marks]

Energy resource	Percentage of UK electricity production	Segment label
Coal	23	
Natural gas	30	
Nuclear power	21	
Oil	1	
Renewable fuels	25	A

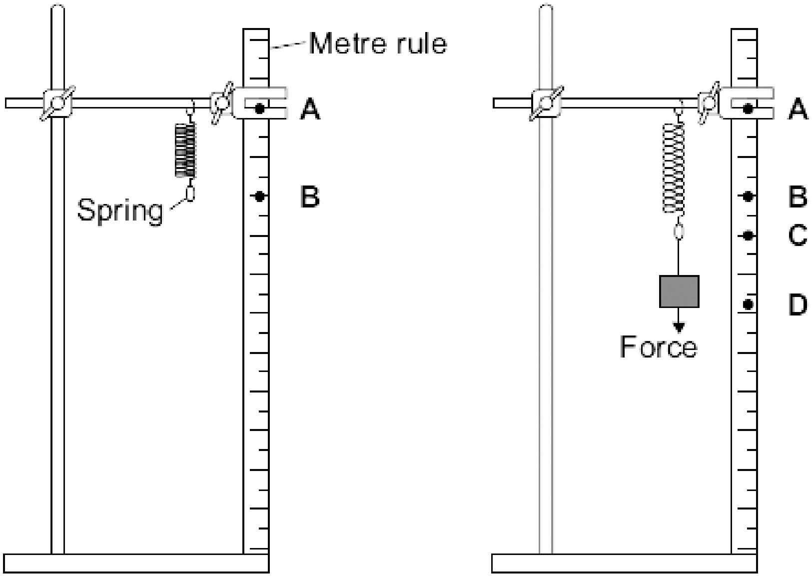
2.2 Over the next 10 years, many of the UK's nuclear power stations are expected to close. Suggest how this may affect the future balance of sources of energy used for electricity production in the UK.

[6 marks]

3.0 A student investigated how the extension of a spring depends on the force applied to the spring.

Figure 2 shows the spring before and after a force has been applied.

Figure 2



3.1 The distance between each large mark on the rule is 10cm. Point **A** is on a large mark.

State the length of the spring and the extension after the force is applied.

[1 mark]

Length of spring = ______________ cm

Extension = ______________ cm

3.2 The stretched spring stores elastic potential energy.
The elastic potential energy stored in a spring can be found by using the equation:

Elastic potential energy = 0.5 × spring constant × (extension)^2

A particular spring has a spring constant of 25 N/m.

Calculate the energy stored when the spring is extended by 15 mm.
Give your answer in standard form, to 3 significant figures.

[3 marks]

Energy stored = ____________ J

3.3 Another student calculated that the energy stored in her spring was twice the amount of energy for half the extension.

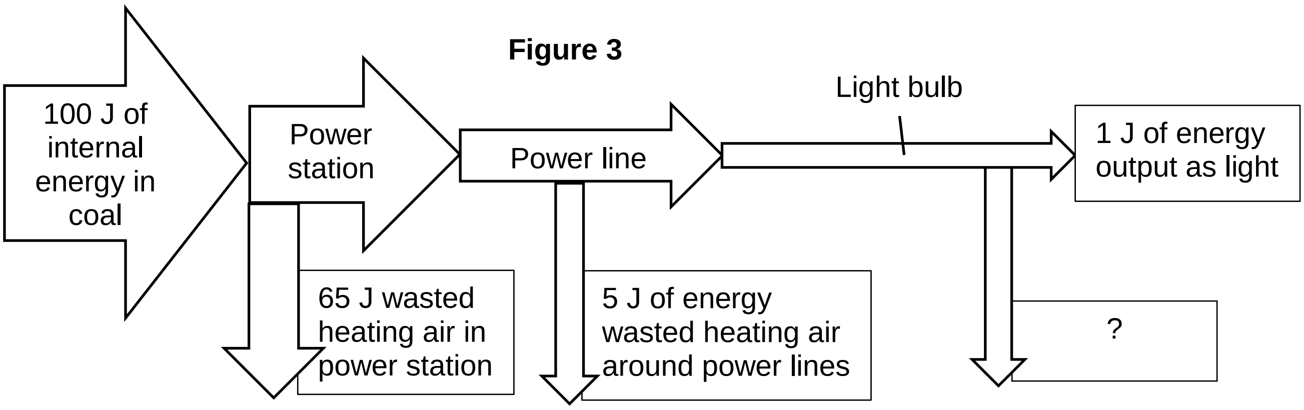
Calculate the spring constant of this spring.

[3 marks]

Spring constant = ____________ N/m

4.0 **Figure 3** shows the amount of energy lost at various stages in producing light from an electric light bulb.

Figure 3



4.1 There is no information on one of the energy labels.

What should it say?

[1 mark]

____

4.2 An electricity company wants to reduce wasted energy across a town.

For the same amount of money, they can either:

- Use 20% of the wasted energy from the power station to heat their offices
- Install new power lines which only waste half the energy of the old ones
- Replace all the bulbs in the town with LED bulbs, which are 99% efficient.

Explain which of these things they should do.

[2 marks]

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____

4.3 The lightbulb's manufacturer says that the lightbulb is 5% efficient. Is this correct?

Use a calculation to justify your answer.

[2 marks]

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4.4 Another lightbulb has a power of 12 W. It has an efficiency of 80%.
Calculate the amount of time taken in seconds for the bulb to transfer 300 J of energy into light energy.

[3 marks]

Time taken = ________________ s

5.1 You have been asked to find out the best material for insulating a hot water tank.

You have three materials: aluminium foil, cotton wool and expanded polystyrene.

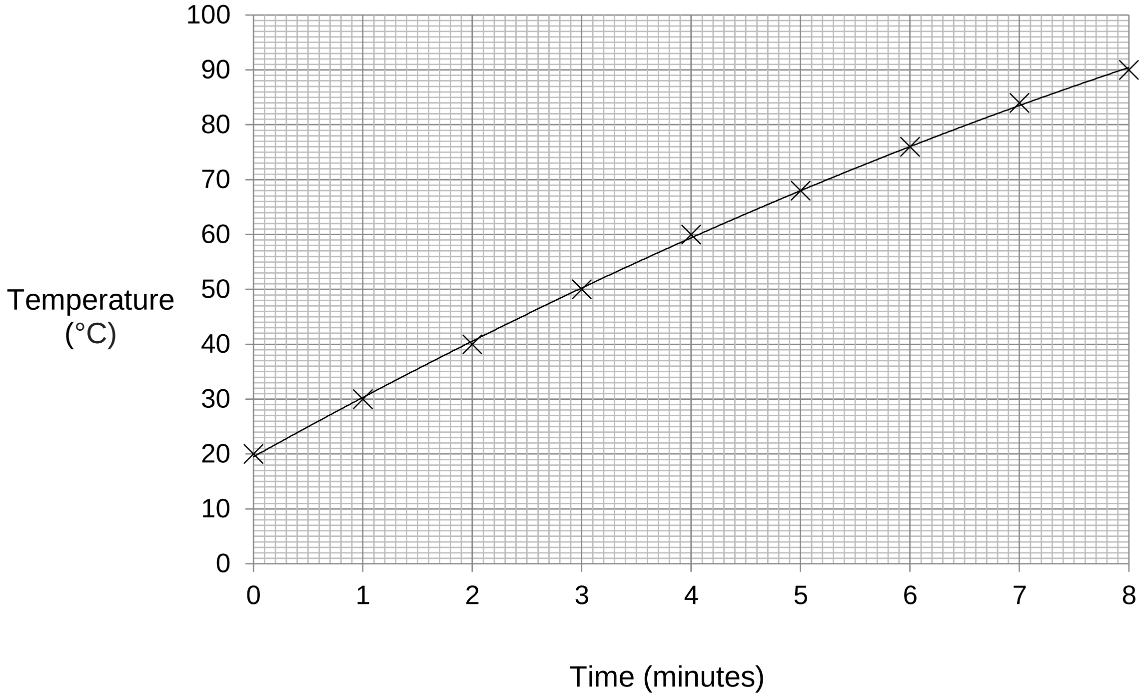
Describe an experiment to compare the effectiveness of these materials.

Include in your description the way you would use your results to decide the most effective material.

[6 marks]

6.0 A student heated a beaker of water and measured the temperature every minute for 8 minutes. **Figure 4** shows the results of their experiment.

Figure 4



6.1 The mass of water used was 450 g.

The power of the heater is 300 W.

Calculate the specific heat capacity of the water.

[3 marks]

Specific heat capacity = ___________ J/kg°C

6.2 The result of this experiment is higher than the accepted value for water.

Suggest **two** reasons why this might be.

[2 marks]

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MARK SCHEME

Qu No.		Extra Information	Marks
1.1	Gravitational potential		1
1.2	Kinetic		1
1.3	50 × 9.8 × 2 – Gravitational potential ½ × 50 × 6.2 × 6.2 – Kinetic	Both required for the mark	1
1.4	Energy lost to the surroundings		1
	Named example (eg air gained internal energy)	Accept heat / air got warmer / sound	1

<table>
<tr><th>Qu No.</th><th></th><th>Extra Information</th><th>Marks</th></tr>
<tr><td>2.1</td><td><table><tr><td>Coal</td><td>C</td></tr><tr><td>Natural gas</td><td>B</td></tr><tr><td>Nuclear power</td><td>E</td></tr><tr><td>Oil</td><td>D</td></tr><tr><td>Renewable fuels</td><td>A</td></tr></table></td><td>2 marks for all four correct
1 mark for 2 correct</td><td>2</td></tr>
<tr><td>2.2</td><td></td><td></td><td></td></tr>
<tr><td>Level 3</td><td colspan="2">Clear, coherently organised answer.
Clear understanding of the overall energy needs of the country.
Understands the need for a range of resources.
Discusses both renewable and non-renewable energy resources, making clear points about each.</td><td>5– 6</td></tr>
<tr><td>Level 2</td><td colspan="2">Some structure to answer.
Some discussion of the overall energy needs of the country.
Discusses a range of resources, giving advantages and disadvantages, although these may not be coherently linked.</td><td>3– 4</td></tr>
<tr><td>Level 1</td><td colspan="2">Limited structure to answer.
Some discussion of a number of resources with limited link to the overall energy needs of the country.</td><td>1– 2</td></tr>
<tr><td>Level 0</td><td colspan="2">No relevant content.</td><td>0</td></tr>
<tr><td colspan="3">Indicative content</td><td></td></tr>
<tr><td colspan="3">• Same or greater overall energy required and/or efficiency savings mean potentially less energy required.
• Fossil fuels plentiful in supply.
• Fossil fuels contribute to global warming.
• Unlikely to be time to set up new nuclear fuel plants.
• Renewable energy resources expensive to set up.
• Renewable energy resources can be inefficient.
• Wave, hydro and/or wind likely to be useful for the UK.
• Solar power less likely to be useful.
• Biomass has negatives in land use and fertilisers etc.

Ignore discussion of nuclear waste etc.</td><td></td></tr>
</table>

Qu No.		Extra Information	Marks
3.1	Length = 20cm Extension = 10cm	Both required for the mark	1
3.2	$0.5 \times 25 \times (15\times10^{-3})^2$ 0.0028125 2.81×10^{-3} (J)	If extension of 15 used, do not allow first mark. ECF allowed: 2812.5 2.81×10^{3} (J)	1 1 1
3.3	Either: Attempt to use value from 3.2: Rearrange $k = E_{pe}/(0.5 \times e^2)$ Substitute $k = \frac{(2 \times 2.81\times10^{-3})}{(0.5 \times (15\times10^{-3}/2)^2}$ k = 200 N/m Or: Algebraic manipulation: Rearrange $k = E_{pe}/(0.5 \times e^2)$ Substitute multiple values $k = 2E_{pe}/(0.5 \times (e/2)^2)$ Cancel and compare with original $k_{new} = 8k_{old}$ = 200 N/m	Allow 199 N/m Allow ECF Allow rounding errors	1 1 1 (1) (1) (1)

Qu No.		Extra Information	Marks
4.1	29 J of energy wasted (from light bulb, heating the air)	OWTTE	1
4.2	Heating offices saves 13 J of energy New powerlines save 2.5 J of energy LED bulbs save 29.7 J of energy So replace lightbulbs	Allow ECF for incorrect bulb wastage in 4.1 All three calculations for 1 mark	1 1
4.3	Use of: $\text{efficiency} = \frac{\text{useful output energy transfer}}{\text{total input energy transfer}}$ 1 / 30 = 0.034 (So not correct)	Allow ECF for incorrect bulb wastage in 4.1 No mark for conclusion.	1 1
4.4	12 × 0.8 = 9.6 Time = energy / power 300 / 9.6 = 31.25 s	Allow 0 or 1 dp	1 1 1

Qu No.		Extra Information	Marks
5.1			
Level 3	Clear, coherently organised answer. Method complete with clear understanding of the experimental requirements and how the data would be analysed.		5-6
Level 2	Some structure to answer. Main steps in method covered, with some errors or omissions. Limited expression of data analysis.		3-4
Level 1	Limited structure to answer. Some steps described, with little or no control variables. No data analysis.		1-2
Level 0	No relevant content.		0
Indicative content			
• Heat a known mass of water. • To a known temperature. • Transfer the water to a beaker lagged with the first material. • Cover the beaker with a lid of the same material. • Record the temperature and start a clock. • Record the temperature drop after a fixed time. • Repeat using the same mass of water with the other materials. • Determine which material has the smallest temperature drop in a given time/longest time for a given temperature drop. • This will be the most effective material.			

Qu No.		Extra Information	Marks
6.1	Energy supplied = power × time = 300 × 8 × 60 = 144×10^3 J Temperature rise = 70°C Mass = 0.45 kg Specific heat capacity = $E/(m.\Delta\theta)$ = $144 \times 10^3/(0.45 \times 70)$ = 4.6×10^3 J/kg °C		1 1 1
6.2	Any **two** from: • Loss of heat to surroundings • Heat absorbed by the beaker • Evaporation • Inaccurate thermometer/clock/balance		2