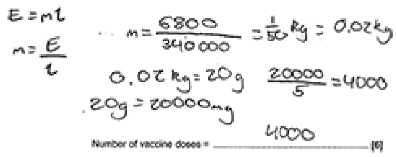
Mark scheme

Question			Answer/Indicative content	Marks	Guidance
1			A	1 (AO 1.1)	**Examiner's Comments** Many candidates found this question challenging. Low-scoring candidates often chose options B or C or D, perhaps not fully understanding the technical words used.
			Total	**1**	
2			A	1 (AO 1.1)	**Examiner's Comments** Many candidates choose the correct response, clearly understanding that energy was needed to change the state of the ice to water, as well as to increase the temperature of the water. A common answer was option C, where candidates had not allowed for energy needed to change state. A small minority of candidates appear to be confused between the difference between the specific latent heat of fusion andthe specific latent heat of vaporisation.
			Total	**1**	
3			B	1 (AO 2.2)	
			Total	**1**	
4	a	i	**First check the answer on answer line** **If answer = 28 500 (J) award 2 marks** ($E = mc\theta$) $E = 0.50 \times 1900 \times 30$ ✓ $E = 28\ 500$ (J) ✓	2 (AO 2.1) (AO 2.1)	**ALLOW** 29 000 J (rounded to 2 significant figures) **ALLOW** 28.5 kJ **Examiner's Comments** This question was answered well. The majority of the candidates correctly determined the temperature change.
		ii	**First check the answer on answer line** **If answer = 95 (W) award 3 marks**	3 (AO 1.2) (AO 2.1) (AO 2.1)	**ALLOW 23(a)(i)** divided by 5 for 2 marks **ALLOW 23(a)(i)** divided by 300 for 3 marks

			P = E ÷ t ✓ P = 28 500 ÷ (5 × 60) ✓ P = 95 (W) ✓		**ALLOW ECF** from **23(a)(i)** **ALLOW** 5700 (W) for 2 marks (no unit conversion) **Examiner's Comments** This question was also answered well. A small minority of candidates did not change the five minutes to 300 seconds. Candidates should be encouraged to think about their calculated values. A power of 5700 W (not changing the time to seconds) is much larger than that of any domestic electrical appliance.
		iii	Containers of vaccines / other contents of the freezer need to be cooled ✓ Energy / heat dissipated / transferred to surroundings / environment or energy heat dissipated in motor / compressor ✓	2 (2 ×AO 3.2a)	**IGNORE** not 100% efficient **Examiner's Comments** Answers were generally vague and many candidates did not gain credit. Many candidates stated that the freezer was not 100% efficient but did not explain why. High scoring candidates often discussed that there was a container for each vaccine or that there were other contents in the freezer. Other candidates discussed the transfer of energy to/from the surroundings or heating in the motor. A common incorrect response was to state the specific heat capacity may be a different value.
	b	i	**Any two from:** Energy is needed to change the state of a material ✓ Energy is needed to break / weaken the bonds (between molecules / particles) or overcome attractive forces (between solid (vaccine) molecules) ✓	2 (2 ×AO 1.2)	**ALLOW** ideas about energy needed to increase separation of molecules **Examiner's Comments** Many candidates scored 1 of the 2

			Some heat transfer with the surroundings / container ✓		marks for stating the energy is needed for a change in state.
		ii	**First check the answer on answer line** **If answer = 4000 (doses) award 6 marks** m = E ÷ L ✓ m = 6800 ÷ 340000 ✓ m = 0.02 kg ✓ 0.02 kg = 20 000 mg✓ (number of doses =) 0.02 ÷ $5x10^{-6}$ OR 20 000 ÷ 5 ✓ (number of doses =) 4000 ✓ **Or** 5 mg = 5×10^{-6} kg ✓ energy of one dose 5 (mg) × 340000 ✓✓ energy of one does = 1.7 J ✓ (number of doses =) 6800 ÷ 1.7 ✓ (number of doses =) 4000 ✓	6 (AO 1.2) (AO 2.1) (AO 2.1) (AO 1.2) (AO 2.1) (AO 3.1b)	Rearrangement of the equation **ALLOW** 0.02 ÷ 5 $\times 10^n$ (missing or incorrect conversion from mg to kg) for 4 marks **ALLOW** 4 × 10^n doses for 5 marks **ALLOW** 5 $\times 10^n$ × 340000 for 2 marks **ALLOW** 1.7 $\times 10^n$ (power of ten error) for 3 marks **ALLOW** 4 × 10^n doses for 5 marks **<u>Examiner's Comments</u>** This question enabled candidates to decide on their own approach to a multi-stage calculation. Clear working should be encouraged. High scoring candidates rearranged the equation before substituting the numbers from the question. Many candidates struggled with the conversion between kg. Some candidates correctly determined the energy needed to melt one dose and then went on to indicate that this worked out to be 4000 doses. This alternative method was correct physics, and thus full credit was given. Exemplar 2

					 The candidate clearly rearranges the equation and substitutes in the correct numbers from the question to determine the mass of vaccine melted (0.02 kg). The candidate then indicates how the mass of 0.02 kg is changed initially to a mass of 20 g before changing it to a mass 20 000 mg. The final calculation is then shown giving the answer of 4000 doses.
			Total	**15**	
5			**C**	1 (AO 2.1)	**<u>Examiner's Comments</u>** Most candidates were able to multiply the numbers together. High scoring candidates often used the white space for their working.
			Total	**1**	
6	a		Bar for kinetic energy higher than zero ✓ Bar for thermal energy higher than previous bar ✓ Sum of the heights of the bars = 5 ✓	3 (3 × AO 2.2)	**DO NOT ALLOW** this mark if candidate has drawn a kinetic energy bar which is higher in Fig. 22.2 **<u>Examiner's Comments</u>** Nearly all candidates scored at least 1 mark (marking point 1), with the majority of candidates scoring two marks (marking point 1 and either marking point 2 or 3). The most common errors included candidates not realising that the total energy in Fig. 22.3 had to add up to 5 J.
	b	i	**Any one from:** Insulate the tube ✓ Repeat (the experiment) **and** take an average (temperature rise) ✓	1 (AO 3.3b)	**ALLOW** use a tube made of a more insulating material

		ii	So pellets do not rub against side of tube / to reduce friction / to reduce thermal energy transfer (to tube)	1 (AO 2.2)	**ALLOW** pellets to fall (more) vertically / to reduce the cooling of the pellets **Examiner's Comments** Fewer than half of candidates scored a mark in part (b) (i). There was a variety of suggestions including repeating the experiment, but this did not score on its own, as candidates also needed to say that they would calculate the mean. Very few candidates answered part (b) (ii) correctly.
		iii	**First check the answer on answer line** **If answer = 0.45 (J) award 2 marks** (GPE =) 0.03 × 10 × 1.5 ✓ (GPE =) 0.45 (J) ✓	2 (AO 2.1) (AO 2.1)	**ALLOW** 0.44 (J) **ALLOW** use of 9.8(1) N / kg **ALLOW** 0.44 (J)
		iv	**First check the answer on answer line** **If answer = 140 J / kg °C award 4 marks** Rearrange to give: c = E / (m × Δθ) ✓ (c =) 21 / (0.03 × 5) ✓ (c =) 140 ✓ J / kg °C ✓	4 (AO 2.1) (AO 2.1) (AO 2.1) (AO 1.1)	**ALLOW** 0.14 J / g °C for 4 marks **ALLOW** K for °C **ALLOW** 1 mark for correct substitution into unrearranged equation, e.g., 21 = 0.03 × c × 5 Unit mark is independent **ALLOW** J / kg / °C **Examiner's Comments** The calculations in both parts (b) (iii) and (b) (iv) were answered very well, with over three quarters of candidates giving the correct numerical answers. The unit of specific heat capacity was less well known. Lower scoring candidates sometimes unnecessarily attempted to change kilograms into grams and metres into centimetres. **Assessment for learning**

					Candidates could benefit from mini-tests on quantities in the specification and their units. **OCR support** Appendix 5e of the specification includes a table of quantities, common symbols, their SI units and their abbreviations. A student friendly printable version is available online and on Teach Cambridge. OCR's Alphabet of physics includes a table that highlights where confusion might otherwise occur. It includes practice questions.
		v	**Any three from:** Student A: A higher SHC would lead to a lower temperature rise/change ✓ (small) temperature rise/change is more difficult to measure ✓ Student B: More turns mean more energy dissipated as thermal energy (in the tube or surroundings) ✓ a larger SHC value is obtained ✓	3 (3 × AO 3.1b)	**Examiner's Comments** It was evident that most candidates found this question, assessing AO3, the most challenging on the paper with only the higher achieving candidates gaining credit. Although nearly all candidates attempted to give an answer, many merely repeated what the students suggested and then stated that they were incorrect, rather than explaining why they were incorrect.
			Total	**14**	
7	a	i	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 480 (J / kg °C) award 4 marks** 24 kJ = 24 000 J ✓ Rearrangement: Specific heat capacity = change in thermal energy ÷ (mass × change in temperature) ✓ (Specific heat capacity =) 24 000 ÷ (2 × 25) ✓	4 (2 × AO1.2) (2 × AO2.1)	**ALLOW** 2 marks for 24 ÷ (2 × 25) or 2.4 × 10^n ÷ (2 × 25) **ALLOW** 3 marks for answer of 0.48 or 4.8 × 10^n (J/kg°C) **Examiner's Comments** This question was answered very well, nearly all candidates scored 3 or 4 marks. The main errors made included:

			(Specific heat capacity =) 480 (J / kg °C) ✓		• incorrectly rearranging the equation • using the starting or final temperature instead of the temperature change • not converting kJ into joules.
		ii	(Idea that) thermal energy is lost/wasted to the surroundings / not all energy supplied to the heater is transferred into the metal block ✓	1(AO3.2a)	**ALLOW** heat for thermal energy **ALLOW** thermal energy is dissipated (to the surroundings)
		iii	**Any one from:** Insulate the metal block ✓ Put the heater further into the metal block / use a smaller heater ✓ Use oil/lubricant to improve contact between heater and block ✓ Repeat and calculate the mean ✓	1(AO3.3b)	**ALLOW** add lid **<u>Examiner's Comments</u>** Candidates usually lost the mark in part (b) (ii) for not giving enough detail in their response, e.g. heat lost on its own was not sufficient, it needed to say that the heat was being lost to the surroundings. Most correct answers referred to insulating the block or repeating the experiment and calculating a mean.
	b		Block C (has the highest specific heat capacity) ✓ It has the smallest change in temperature (for the same rate of input in energy) ✓	2 (AO3.1b) (AO3.1b)	No mark if block A or B chosen **ALLOW** it has the lowest gradient/slope **ALLOW** it has the slowest change in temperature **IGNORE** (idea that) it needs more energy to raise temperature by 1°C **<u>Examiner's Comments</u>** This AO3 question assessed candidates' ability to interpret the temperature-time graph and draw the correct conclusions about which metal had the highest specific heat capacity. Most candidates scored zero, as they identified the wrong metal, or 2 marks. Responses that gained just 1 mark usually included the idea that block C needed more energy to raise the temperature by 1 °C. This did not score as it was based on the definition of specific heat capacity and not what was shown by the graph.

			Total	**8**	
8			C ✓	1 (AO2.1)	
			Total	**1**	
9			C ✓	1 (AO1.2)	**<u>Examiner's Comments</u>** A minority of candidates selected B or D. **Assessment for learning** Understand the difference between latent heat and specific heat capacity. This question could be used without the labels for candidates to identify the processes that occur in each section of the graph.
			Total	**1**	