2 This question is about energy changes involved in the formation of ionic compounds.

(a) What is the order of increasing first ionisation energy for the elements beryllium, helium and lithium?

(1)

☒ **A** lithium < helium < beryllium

☒ **B** beryllium < lithium < helium

☒ **C** helium < beryllium < lithium

☒ **D** lithium < beryllium < helium

(b) The **second** ionisation energy of calcium has a magnitude of 1150 kJ mol^{-1}.

Which of the following represents the **second** ionisation energy of calcium?

(1)

☒ **A** $Ca(g) \rightarrow Ca^{2+}(g) + 2e^-$ $\Delta H^{\ominus} = +1150$ kJ mol^{-1}

☒ **B** $Ca^+(g) \rightarrow Ca^{2+}(g) + e^-$ $\Delta H^{\ominus} = +1150$ kJ mol^{-1}

☒ **C** $Ca(g) \rightarrow Ca^{2+}(g) + 2e^-$ $\Delta H^{\ominus} = -1150$ kJ mol^{-1}

☒ **D** $Ca^+(g) \rightarrow Ca^{2+}(g) + e^-$ $\Delta H^{\ominus} = -1150$ kJ mol^{-1}

(c) The formation of potassium ions can be represented by the equation

$$K(s) \rightarrow K^+(g) + e^-$$

Which statement corresponds to the energy change for this process?

(1)

☒ **A** the first electron affinity of potassium

☒ **B** the first ionisation energy of potassium

☒ **C** the sum of the enthalpy change of atomisation of potassium and the first electron affinity of potassium

☒ **D** the sum of the enthalpy change of atomisation of potassium and the first ionisation energy of potassium

(d) The table shows the ionic radius and charge of each of six ions.

Ion	D^+	E^+	G^{2+}	X^-	Y^-	Z^{2-}
Ionic radius / nm	0.14	0.18	0.15	0.14	0.18	0.15

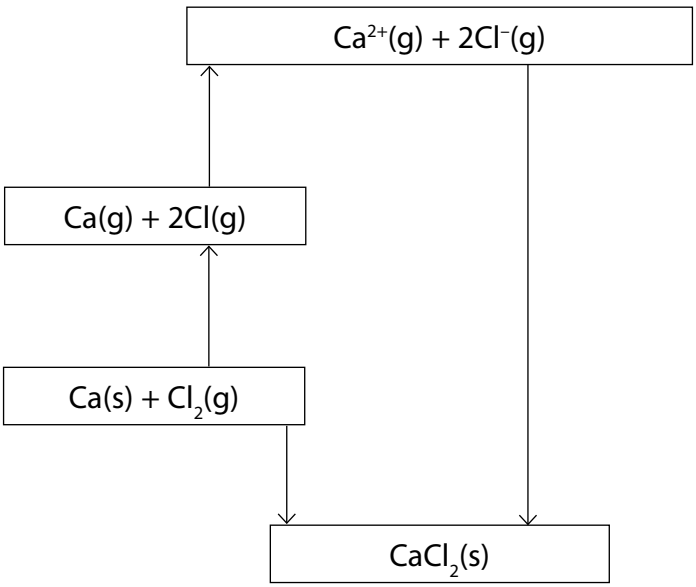
The ionic solids DX, EY and GZ have the same lattice structure.

Deduce the order of magnitude of their lattice energies, giving the most exothermic first.

Justify your answer.

(3)

(e) The diagram shows a Born-Haber cycle for calcium chloride, $CaCl_2$.



	kJ mol^{-1}
Enthalpy of formation of $CaCl_2(s)$	–796
Lattice energy of $CaCl_2(s)$	–2258
Enthalpy of atomisation of $Ca(s) \rightarrow Ca(g)$	178
Enthalpy of atomisation of $\frac{1}{2}Cl_2(g) \rightarrow Cl(g)$	122
First ionisation energy of Ca(g)	590
Electron affinity of Cl(g)	–349

Calculate the second ionisation energy of calcium, in kJ mol^{-1}.

(2)

(Total for Question 2 = 8 marks)