Assignments regarding The Freezing Process - Calculations

Calculating the Freezing Process
Calculate the following Physical Properties for fresh/frozen produce/products of your choice (Protein/Fat/Carbohydrate rich products), Specific Heat Capacity, Density, Enthalpy at Reference Temperature $T=0^\circ$C, Enthalpy at Reference Temperature $T=-40^\circ$C (difficult problem!), Thermal Conductivity of frozen Products, Thermal Diffusivity $\alpha$ of frozen Product as function of $\lambda$, $\rho$ and $cp$.

The produce/products:
- Cod,
- Spinach,
- Strawberry,
- Wheat (whole grain).

The freezing process/freezing time (a)
Calculate the freezing time for pieces of protein/fat/carbohydrate rich products for the following individual conditions:
- Weight of sample 2 kg
- Characteristic shapes

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Plate</th>
<th>Cylinder</th>
</tr>
</thead>
<tbody>
<tr>
<td>Characteristic thickness X/m</td>
<td>0.05</td>
<td>0.1</td>
</tr>
</tbody>
</table>

Heat transfer Coefficients $\alpha$ (W/m2K): 2.000; 100; 10.
(First question to answer: how many answers are required?).

If you consider the cylinder in the above problem placed with its basis on a heat exchanger surface and surrounded by a cold atmosphere, where will be the thermal centre on the middle axis in case of the following heat transfer situation:

<table>
<thead>
<tr>
<th>Basic Heat transfer Situation</th>
<th>Heat exchanger surface Heat transfer Coefficient W/m2K</th>
<th>Surrounding cold atmosphere Heat transfer Coefficient W/m2K</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3.000</td>
<td>30</td>
</tr>
<tr>
<td>2</td>
<td>2.000</td>
<td>10</td>
</tr>
<tr>
<td>3</td>
<td>300</td>
<td>3</td>
</tr>
</tbody>
</table>

The calculation should be carried out for all 9 possible situations.

The freezing process/freezing time (b)
Try to develop a model of a situation where different heat transfer conditions prevail e.g. a cylindrical object is located with its basis on a metallic plate with a high heat transfer coefficient, the cylinder itself is surrounded by cold air with a low heat transfer coefficient.
Calculate the freezing btime.