Questão 1

In [19]:

```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
from sklearn.datasets import load_breast_cancer
from sklearn.cluster import AgglomerativeClustering

cancer_data = load_breast_cancer()
df = pd.DataFrame(cancer_data.data, columns=cancer_data.feature_names)
df.head()
```

Out[19]:

	mean radius	mean texture	mean perimeter	mean area	mean smoothness	mean compactness	mean concavity	mean concave points	mean symmetry	mean fractal dimension	...	worst radius	worst texture	worst perimeter
0	17.99	10.38	122.80	1001.0	0.11840	0.27760	0.3001	0.14710	0.2419	0.07871	...	25.38	17.33	184.60
1	20.57	17.77	132.90	1326.0	0.08474	0.07864	0.0869	0.07017	0.1812	0.05667	...	24.99	23.41	158.80
2	19.69	21.25	130.00	1203.0	0.10960	0.15990	0.1974	0.12790	0.2069	0.05999	...	23.57	25.53	152.50
3	11.42	20.38	77.58	386.1	0.14250	0.28390	0.2414	0.10520	0.2597	0.09744	...	14.91	26.50	98.87
4	20.29	14.34	135.10	1297.0	0.10030	0.13280	0.1980	0.10430	0.1809	0.05883	...	22.54	16.67	152.20

5 rows × 30 columns

In [20]:

```
df['target'] = cancer_data.target
df.target.value_counts()
```

Out[20]:

	count
target	
1	357
0	212

dtype: int64

In [21]:

```
features = df.drop('target', axis=1)

agg_clustering = AgglomerativeClustering()
agg_clustering.fit(features)

cluster_labels = agg_clustering.fit_predict(features)

df['cluster'] = cluster_labels

print(df.head())
```

```
   mean radius  mean texture  mean perimeter  mean area  mean smoothness  \
0        17.99         10.38          122.80     1001.0          0.11840   
1        20.57         17.77          132.90     1326.0          0.08474   
2        19.69         21.25          130.00     1203.0          0.10960   
3        11.42         20.38           77.58      386.1          0.14250   
4        20.29         14.34          135.10     1297.0          0.10030   

   mean compactness  mean concavity  mean concave points  mean symmetry  \
0           0.27760          0.3001              0.14710         0.2419   
1           0.07864          0.0869              0.07017         0.1812   
2           0.15990          0.1974              0.12790         0.2069   
3           0.28390          0.2414              0.10520         0.2597   
4           0.13280          0.1980              0.10430         0.1809   

   mean fractal dimension  ...  worst perimeter  worst area  worst smoothness  \
0                 0.07871  ...           184.60      2019.0            0.1622   
1                 0.05667  ...           158.80      1956.0            0.1238   
2                 0.05999  ...           152.50      1709.0            0.1444   
3                 0.09744  ...            98.87       567.7            0.2098   
4                 0.05883  ...           152.20      1575.0            0.1374   

   worst compactness  worst concavity  worst concave points  worst symmetry  \
0             0.6656           0.7119                0.2654          0.4601   
1             0.1866           0.2416                0.1860          0.2750   
2             0.4245           0.4504                0.2430          0.3613   
3             0.8663           0.6869                0.2575          0.6638   
4             0.2050           0.4000                0.1625          0.2364   

   worst fractal dimension  target  cluster  
0                  0.11890       0        1  
1                  0.08902       0        1  
2                  0.08758       0        1  
3                  0.17300       0        0  
4                  0.07678       0        1  

[5 rows x 32 columns]
```

In [22]:

```
contingency_table = pd.crosstab(df['target'], df['cluster'])

contingency_table
```

Out[22]:

cluster	0	1
target		
0	126	86
1	357	0

Questão 2

In [25]:

```
k_range = range(2, 11)
sse = []
for k in k_range:
    agg_clustering = AgglomerativeClustering(n_clusters=k, linkage='ward')

    cluster_labels = agg_clustering.fit_predict(features)

    contingency_table = pd.crosstab(df['target'], cluster_labels)
    print(f"--- Clusters: {k} ---")
    print(contingency_table)
    print()

    current_sse = 0
    for i in range(k):
        points_in_cluster = features[cluster_labels == i]
        centroid = points_in_cluster.mean(axis=0)
        current_sse += np.sum((points_in_cluster - centroid) ** 2).sum()

    sse.append(current_sse)
```

```
--- Clusters: 2 ---
col_0     0   1
target
0       126  86
1       357   0

--- Clusters: 3 ---
col_0    0    1    2
target
0       86  120    6
1        0   97  260

--- Clusters: 4 ---
col_0     0   1    2   3
target
0       120  75    6  11
1        97   0  260   0

--- Clusters: 5 ---
col_0    0   1    2   3   4
target
0       75  11    6  64  56
1        0   0  260  96   1

--- Clusters: 6 ---
col_0     0   1   2   3   4   5
target
0         6  11  29  64  56  46
1       260   0   0  96   1   0

--- Clusters: 7 ---
col_0    0   1   2    3   4   5    6
target
0       11  64  29    2  56  46    4
1        0  96   0  128   1   0  132

--- Clusters: 8 ---
col_0    0    1   2   3   4   5    6  7
target
0       64    2  29  10  56  46    4  1
1       96  128   0   0   1   0  132  0
```

```
--- Clusters: 9 ---
col_0    0    1   2   3   4   5    6  7   8
target
0       29    2  46  10  56  34    4  1  30
1        0  128   0   0   1  80  132  0  16

--- Clusters: 10 ---
col_0     0   1   2   3  4   5    6  7   8   9
target
0         2  56  46  10  9  34    4  1  30  20
1       128   1   0   0  0  80  132  0  16   0
```

```
/usr/local/lib/python3.12/dist-packages/numpy/_core/fromnumeric.py:84: FutureWarning: The behavior of DataFrame.sum
with axis=None is deprecated, in a future version this will reduce over both axes and return a scalar. To retain the
old behavior, pass axis=0 (or do not pass axis)
  return reduction(axis=axis, out=out, **passkwargs)
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  return reduction(axis=axis, out=out, **passkwargs)
```
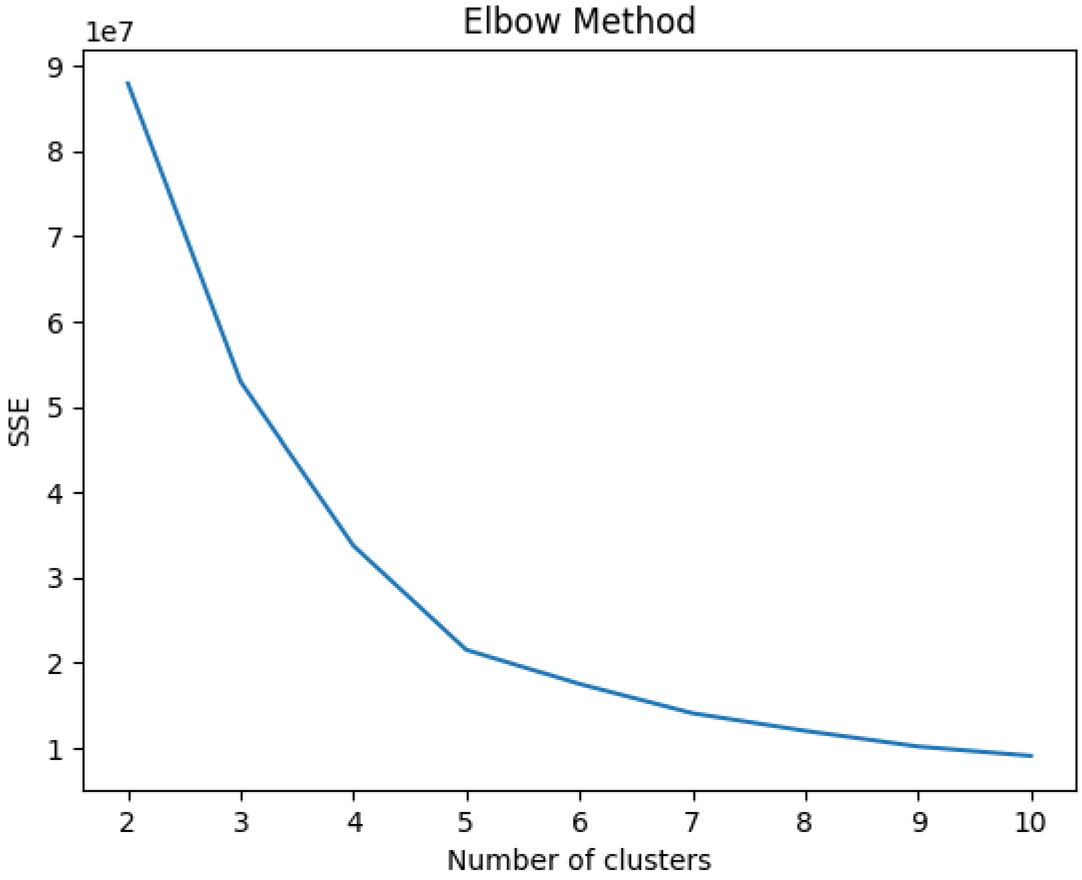

In [27]:

```
plt.plot(k_range, sse)
plt.title('Elbow Method')
plt.xlabel('Number of clusters')
plt.ylabel('SSE')
plt.show()
```


Elbow Method
1e7
SSE
Number of clusters