Ensemble Learning

Imports 👇

In [55]:
```
import pandas
import numpy
from sklearn import svm
from sklearn.ensemble import BaggingClassifier
import xgboost
from sklearn.ensemble import RandomForestClassifier
from sklearn.ensemble import GradientBoostingClassifier
from sklearn.metrics import confusion_matrix,classification_report
import seaborn
import matplotlib.pyplot as pyplot
```

👇 *setting the matplotlib configurations*

In [254]:
```
%matplotlib inline
pyplot.rcParams["figure.figsize"] = (8, 5)
```

Data Reading 👇

In [191]:
```
# this are the output classes, only two classes are there paitient will dead or alive
classes_list=['Not_Failed','Failed']
```

In [192]:
```
data=pandas.read_csv('./Brain_failure_healthcare-dataset-stroke-data.csv')
```

👇 cheking the columns, data, data type information, correlation between attributes

In [193]:
```
data.columns
```

Out[193]:
```
Index(['id', 'gender', 'age', 'hypertension', 'heart_disease', 'ever_married',
       'work_type', 'Residence_type', 'avg_glucose_level', 'bmi',
       'smoking_status', 'stroke'],
      dtype='object')
```

In [194]:
```
data['stroke'].value_counts()
```

Out[194]:
```
0    4861
1     249
Name: stroke, dtype: int64
```

In [195]:
```
data
```

Out[195]:

	id	gender	age	hypertension	heart_disease	ever_married	work_type	Residence_type	avg_glucose_level	bmi	smoking_status	stroke
0	9046	Male	67.0	0	1	Yes	Private	Urban	228.69	36.6	formerly smoked	1
1	51676	Female	61.0	0	0	Yes	Self-employed	Rural	202.21	NaN	never smoked	1
2	31112	Male	80.0	0	1	Yes	Private	Rural	105.92	32.5	never smoked	1
3	60182	Female	49.0	0	0	Yes	Private	Urban	171.23	34.4	smokes	1
4	1665	Female	79.0	1	0	Yes	Self-employed	Rural	174.12	24.0	never smoked	1
...	...	...	...	...	...	...	...	...	...	...	...	...
5105	18234	Female	80.0	1	0	Yes	Private	Urban	83.75	NaN	never smoked	0
5106	44873	Female	81.0	0	0	Yes	Self-employed	Urban	125.20	40.0	never smoked	0
5107	19723	Female	35.0	0	0	Yes	Self-employed	Rural	82.99	30.6	never smoked	0
5108	37544	Male	51.0	0	0	Yes	Private	Rural	166.29	25.6	formerly smoked	0
5109	44679	Female	44.0	0	0	Yes	Govt_job	Urban	85.28	26.2	Unknown	0

5110 rows × 12 columns

In [196]:
```
data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 5110 entries, 0 to 5109
Data columns (total 12 columns):
 #   Column             Non-Null Count  Dtype  
---  ------             --------------  -----  
 0   id                 5110 non-null   int64  
 1   gender             5110 non-null   object 
 2   age                5110 non-null   float64
 3   hypertension       5110 non-null   int64  
 4   heart_disease      5110 non-null   int64  
 5   ever_married       5110 non-null   object 
 6   work_type          5110 non-null   object 
 7   Residence_type     5110 non-null   object 
 8   avg_glucose_level  5110 non-null   float64
 9   bmi                4909 non-null   float64
 10  smoking_status     5110 non-null   object 
 11  stroke             5110 non-null   int64  
dtypes: float64(3), int64(4), object(5)
memory usage: 479.2+ KB
```

In [197]:
```
data.describe()
```

Out[197]:

	id	age	hypertension	heart_disease	avg_glucose_level	bmi	stroke
count	5110.000000	5110.000000	5110.000000	5110.000000	5110.000000	4909.000000	5110.000000
mean	36517.829354	43.226614	0.097456	0.054012	106.147677	28.893237	0.048728
std	21161.721625	22.612647	0.296607	0.226063	45.283560	7.854067	0.215320
min	67.000000	0.080000	0.000000	0.000000	55.120000	10.300000	0.000000
25%	17741.250000	25.000000	0.000000	0.000000	77.245000	23.500000	0.000000
50%	36932.000000	45.000000	0.000000	0.000000	91.885000	28.100000	0.000000
75%	54682.000000	61.000000	0.000000	0.000000	114.090000	33.100000	0.000000
max	72940.000000	82.000000	1.000000	1.000000	271.740000	97.600000	1.000000

In [198]:
```
data.corr()
```

Out[198]:

	id	age	hypertension	heart_disease	avg_glucose_level	bmi	stroke
id	1.000000	0.003538	0.003550	-0.001296	0.001092	0.003084	0.006388
age	0.003538	1.000000	0.276398	0.263796	0.238171	0.333398	0.245257
hypertension	0.003550	0.276398	1.000000	0.108306	0.174474	0.167811	0.127904
heart_disease	-0.001296	0.263796	0.108306	1.000000	0.161857	0.041357	0.134914
avg_glucose_level	0.001092	0.238171	0.174474	0.161857	1.000000	0.175502	0.131945
bmi	0.003084	0.333398	0.167811	0.041357	0.175502	1.000000	0.042374
stroke	0.006388	0.245257	0.127904	0.134914	0.131945	0.042374	1.000000

Dimentiality reduction

In [199]:
```
data=data.drop(['id','bmi'],axis=1)
```

data Cleaning

In [200]:
```
data=data.replace("Male",1)
data=data.replace("Female",0)
data=data.replace("Other",0)


data=data.drop(['ever_married','work_type','Residence_type'],axis=1)

data=data.replace("never smoked",0)
data=data.replace("Unknown",0)
data=data.replace("formerly smoked",1)
data=data.replace("smokes",1)
```

Data Visualization 👇

In [201]:
```
data
```

Out[201]:

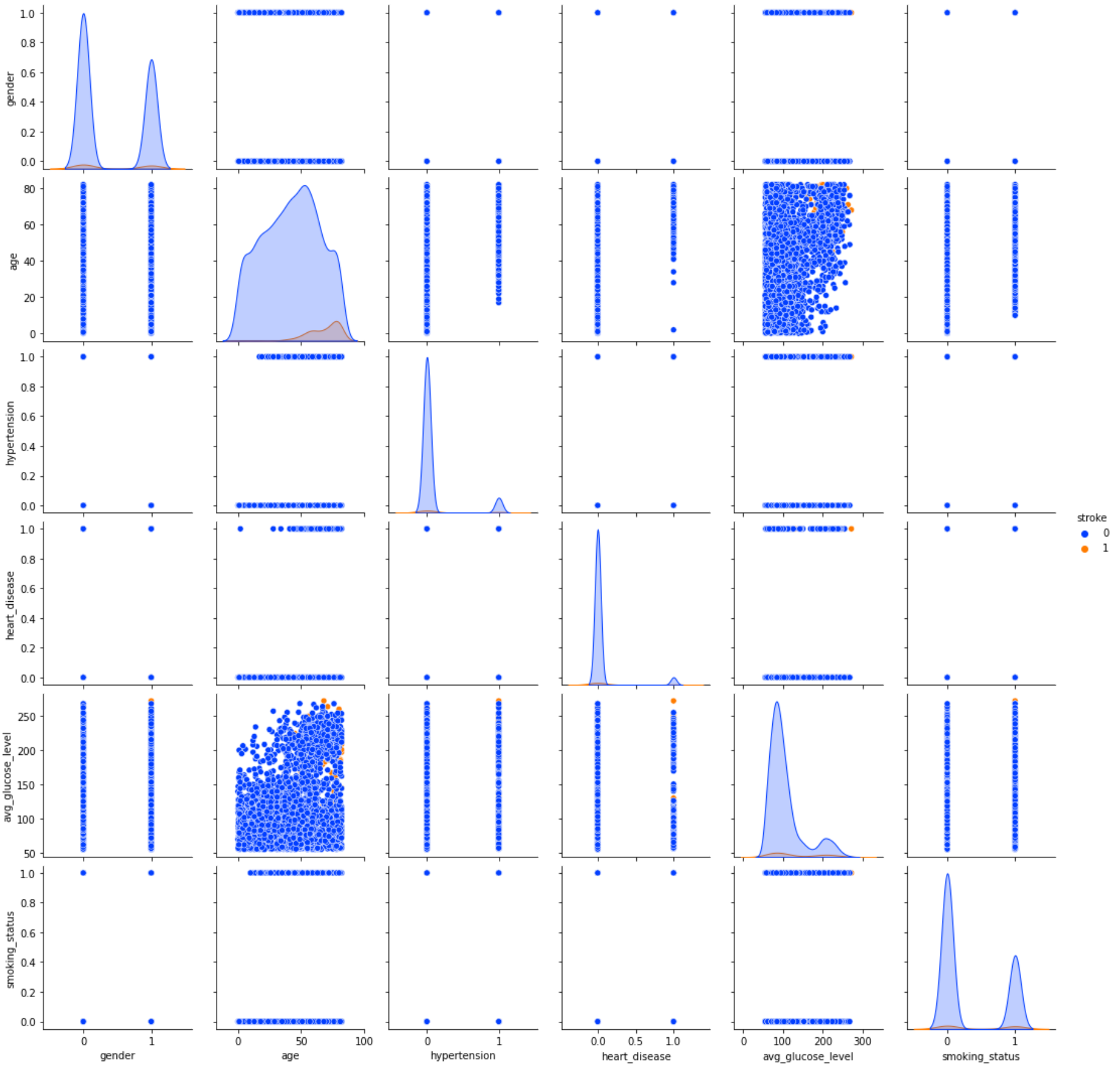
	gender	age	hypertension	heart_disease	avg_glucose_level	smoking_status	stroke
0	1	67.0	0	1	228.69	1	1
1	0	61.0	0	0	202.21	0	1
2	1	80.0	0	1	105.92	0	1
3	0	49.0	0	0	171.23	1	1
4	0	79.0	1	0	174.12	0	1
...	...	...	...	...	...	...	...
5105	0	80.0	1	0	83.75	0	0
5106	0	81.0	0	0	125.20	0	0
5107	0	35.0	0	0	82.99	0	0
5108	1	51.0	0	0	166.29	1	0
5109	0	44.0	0	0	85.28	0	0

5110 rows × 7 columns

👇 checking the available number of classes

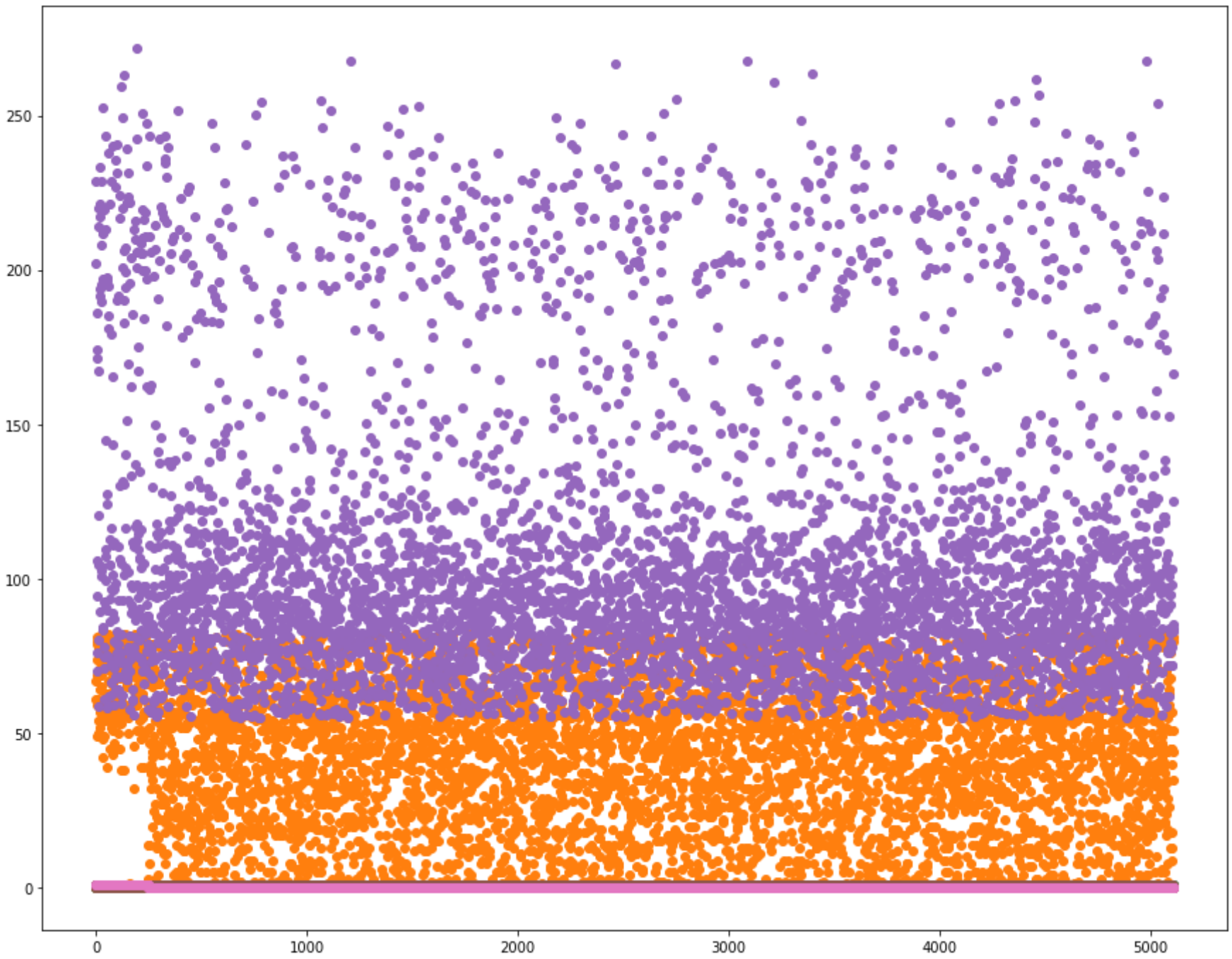
In [202]:
```
seaborn.pairplot(data.iloc[:,:7], hue="stroke",palette="bright")
```

Out[202]:
```
<seaborn.axisgrid.PairGrid at 0x20f02a0ef70>
```



In [203]:
```
pyplot.scatter(x=[i for i in range(1,len(data)+1)],y=data.iloc[:,0])
pyplot.scatter(x=[i for i in range(1,len(data)+1)],y=data.iloc[:,1])
pyplot.scatter(x=[i for i in range(1,len(data)+1)],y=data.iloc[:,2])
pyplot.scatter(x=[i for i in range(1,len(data)+1)],y=data.iloc[:,3])
pyplot.scatter(x=[i for i in range(1,len(data)+1)],y=data.iloc[:,4])
pyplot.scatter(x=[i for i in range(1,len(data)+1)],y=data.iloc[:,5])
pyplot.scatter(x=[i for i in range(1,len(data)+1)],y=data.iloc[:,6])
```

Out[203]: <matplotlib.collections.PathCollection at 0x20f06d23130>



Data Preparation

Suffling the data set 👇

this is to get splitted data, that have all type of the classes in training and testing

In [205]:
```
shuffled_Data=data.sample(frac=1)
```

Splitting the dataset into training and testing 👇

For Training 85% data is being used and for testing 15% data is used from the given data

In [206]:
```
training_value=int(len(shuffled_Data)*0.85)
```

In [207]:
```
Training_Data = shuffled_Data[:training_value]
Testing_Data = shuffled_Data[training_value:]
```

In [208]:
```
Training_Data['stroke'].value_counts()
```

Out[208]:
```
0    4133
1     210
Name: stroke, dtype: int64
```

In [209]:
```
Training_Data
```

Out[209]:

	gender	age	hypertension	heart_disease	avg_glucose_level	smoking_status	stroke
546	1	9.0	0	0	122.22	0	0
4933	0	81.0	0	0	80.44	0	0
2112	1	13.0	0	0	74.19	1	0
2740	1	15.0	0	0	79.59	0	0
5017	0	58.0	0	0	69.12	0	0
...	...	...	...	...	...	...	...
3289	0	44.0	0	0	86.15	0	0
2281	0	47.0	0	0	131.43	0	0
1004	1	39.0	0	0	72.49	1	0
3568	1	39.0	1	0	88.18	1	0
1346	1	49.0	0	0	199.96	0	0

4343 rows × 7 columns

Dividing the training data features and labels 👇

this will be used for training of model

In [210]:
```
training_Labels=Training_Data['stroke']
training_Features=Training_Data.drop(['stroke'],axis=1)
```

In [211]:
```
training_Features.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 4343 entries, 546 to 1346
Data columns (total 6 columns):
 #   Column             Non-Null Count  Dtype  
---  ------             --------------  -----  
 0   gender             4343 non-null   int64  
 1   age                4343 non-null   float64
 2   hypertension       4343 non-null   int64  
 3   heart_disease      4343 non-null   int64  
 4   avg_glucose_level  4343 non-null   float64
 5   smoking_status     4343 non-null   int64  
dtypes: float64(2), int64(4)
memory usage: 237.5 KB
```

In [212]:
```
training_Labels.value_counts()
```

Out[212]:
```
0    4133
1     210
Name: stroke, dtype: int64
```

dividing the testing data features and labels 👇

this will be used for testing the model

In [213]:
```
testing_Labels=Testing_Data['stroke']
testing_Features=Testing_Data.drop(['stroke'],axis=1)
```

In [214]:
```
testing_Features.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 767 entries, 2081 to 2831
Data columns (total 6 columns):
 #   Column             Non-Null Count  Dtype  
---  ------             --------------  -----  
 0   gender             767 non-null    int64  
 1   age                767 non-null    float64
 2   hypertension       767 non-null    int64  
 3   heart_disease      767 non-null    int64  
 4   avg_glucose_level  767 non-null    float64
 5   smoking_status     767 non-null    int64  
dtypes: float64(2), int64(4)
memory usage: 41.9 KB
```

In [215]:
```
testing_Labels.value_counts()
```

Out[215]:
```
0    728
1     39
Name: stroke, dtype: int64
```

Bagging

Creating the SVM instance and it is given to bagging classifier 👇

so for bagging will apply SVM model multiple time and output will be given by combination of all

In [216]:
```
svmmodel=svm.LinearSVC()
bagging_classifier = BaggingClassifier(base_estimator=svmmodel)
```

fitting the model 👇

In [217]:
```
bagging_classifier.fit(training_Features,training_Labels)
```

```
C:\Users\Pankaj singh\AppData\Roaming\Python\Python39\site-packages\sklearn\svm\_base.py:985: ConvergenceWarning: Libli
near failed to converge, increase the number of iterations.
  warnings.warn("Liblinear failed to converge, increase "
C:\Users\Pankaj singh\AppData\Roaming\Python\Python39\site-packages\sklearn\svm\_base.py:985: ConvergenceWarning: Libli
near failed to converge, increase the number of iterations.
  warnings.warn("Liblinear failed to converge, increase "
C:\Users\Pankaj singh\AppData\Roaming\Python\Python39\site-packages\sklearn\svm\_base.py:985: ConvergenceWarning: Libli
near failed to converge, increase the number of iterations.
  warnings.warn("Liblinear failed to converge, increase "
C:\Users\Pankaj singh\AppData\Roaming\Python\Python39\site-packages\sklearn\svm\_base.py:985: ConvergenceWarning: Libli
near failed to converge, increase the number of iterations.
  warnings.warn("Liblinear failed to converge, increase "
C:\Users\Pankaj singh\AppData\Roaming\Python\Python39\site-packages\sklearn\svm\_base.py:985: ConvergenceWarning: Libli
near failed to converge, increase the number of iterations.
  warnings.warn("Liblinear failed to converge, increase "
C:\Users\Pankaj singh\AppData\Roaming\Python\Python39\site-packages\sklearn\svm\_base.py:985: ConvergenceWarning: Libli
near failed to converge, increase the number of iterations.
  warnings.warn("Liblinear failed to converge, increase "
C:\Users\Pankaj singh\AppData\Roaming\Python\Python39\site-packages\sklearn\svm\_base.py:985: ConvergenceWarning: Libli
near failed to converge, increase the number of iterations.
  warnings.warn("Liblinear failed to converge, increase "
C:\Users\Pankaj singh\AppData\Roaming\Python\Python39\site-packages\sklearn\svm\_base.py:985: ConvergenceWarning: Libli
near failed to converge, increase the number of iterations.
  warnings.warn("Liblinear failed to converge, increase "
C:\Users\Pankaj singh\AppData\Roaming\Python\Python39\site-packages\sklearn\svm\_base.py:985: ConvergenceWarning: Libli
near failed to converge, increase the number of iterations.
  warnings.warn("Liblinear failed to converge, increase "
C:\Users\Pankaj singh\AppData\Roaming\Python\Python39\site-packages\sklearn\svm\_base.py:985: ConvergenceWarning: Libli
near failed to converge, increase the number of iterations.
  warnings.warn("Liblinear failed to converge, increase "
```

Out[217]:
```
BaggingClassifier(base_estimator=LinearSVC())
```

Optional Part 👇

checking model on training data to check training accuracy (not needed)

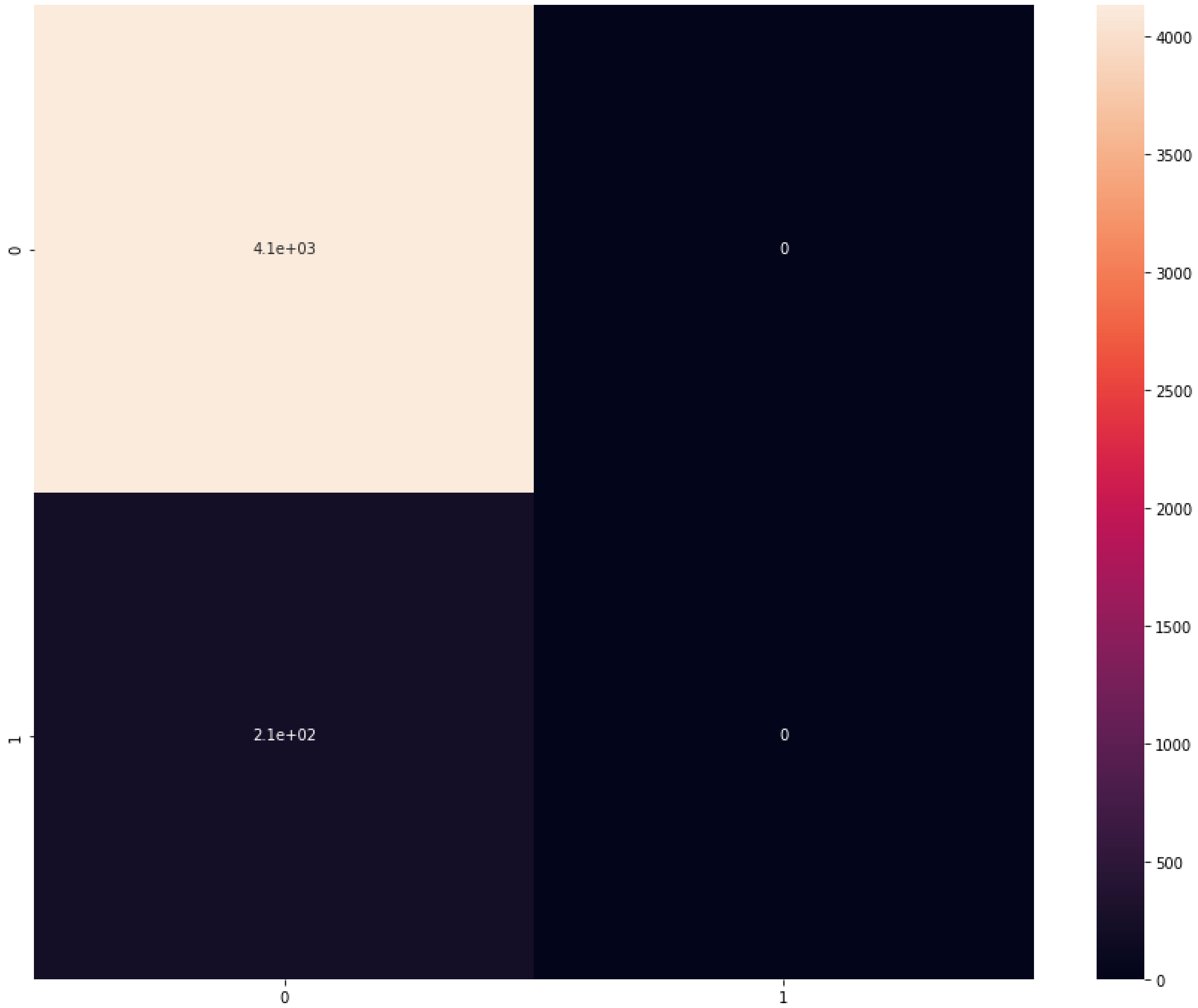
In [218]:
```
training_predicted_values=bagging_classifier.predict(training_Features)
training_classification_data=confusion_matrix(training_Labels,training_predicted_values)
seaborn.heatmap(training_classification_data,annot=True)
print(classification_report(training_Labels,training_predicted_values))
```

```
              precision    recall  f1-score   support

           0       0.95      1.00      0.98      4133
           1       0.00      0.00      0.00       210

    accuracy                           0.95      4343
   macro avg       0.48      0.50      0.49      4343
weighted avg       0.91      0.95      0.93      4343


C:\Users\Pankaj singh\AppData\Roaming\Python\Python39\site-packages\sklearn\metrics\_classification.py:1248: UndefinedM
etricWarning: Precision and F-score are ill-defined and being set to 0.0 in labels with no predicted samples. Use `zero
_division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
C:\Users\Pankaj singh\AppData\Roaming\Python\Python39\site-packages\sklearn\metrics\_classification.py:1248: UndefinedM
etricWarning: Precision and F-score are ill-defined and being set to 0.0 in labels with no predicted samples. Use `zero
_division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
C:\Users\Pankaj singh\AppData\Roaming\Python\Python39\site-packages\sklearn\metrics\_classification.py:1248: UndefinedM
etricWarning: Precision and F-score are ill-defined and being set to 0.0 in labels with no predicted samples. Use `zero
_division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
```



Training accuracy is 89%

Now Testing the model 👇

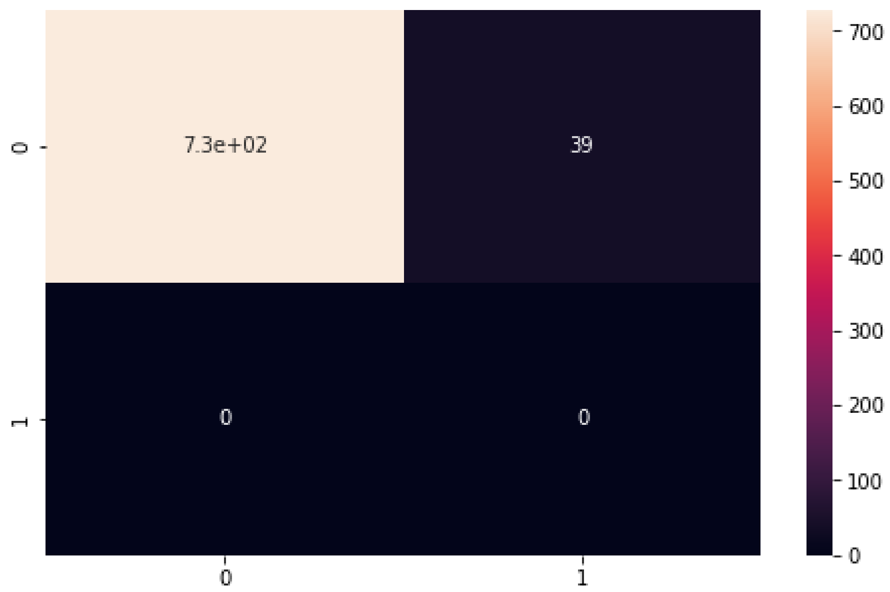
In [255]:
```
predicted_values=bagging_classifier.predict(testing_Features)
classification_data=confusion_matrix(predicted_values,testing_Labels)
seaborn.heatmap(classification_data,annot=True)
print(classification_report(testing_Labels,predicted_values))
```

```
              precision    recall  f1-score   support

           0       0.95      1.00      0.97       728
           1       0.00      0.00      0.00        39

    accuracy                           0.95       767
   macro avg       0.47      0.50      0.49       767
weighted avg       0.90      0.95      0.92       767


C:\Users\Pankaj singh\AppData\Roaming\Python\Python39\site-packages\sklearn\metrics\_classification.py:1248: UndefinedM
etricWarning: Precision and F-score are ill-defined and being set to 0.0 in labels with no predicted samples. Use `zero
_division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
C:\Users\Pankaj singh\AppData\Roaming\Python\Python39\site-packages\sklearn\metrics\_classification.py:1248: UndefinedM
etricWarning: Precision and F-score are ill-defined and being set to 0.0 in labels with no predicted samples. Use `zero
_division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
C:\Users\Pankaj singh\AppData\Roaming\Python\Python39\site-packages\sklearn\metrics\_classification.py:1248: UndefinedM
etricWarning: Precision and F-score are ill-defined and being set to 0.0 in labels with no predicted samples. Use `zero
_division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
```



Following will show that what is actual value and what is predicted by model 👇

In [220]:
```
predicted_values=list(predicted_values)
testing_Labels=list(testing_Labels)
print("Actual Values --> Predicted values")
for i in range(len(predicted_values)):
    print("     ",testing_Labels[i]," --> ",predicted_values[i])
```

```
      0  -->  0
      1  -->  0
      0  -->  0
      0  -->  0
      0  -->  0
      0  -->  0
      0  -->  0
      0  -->  0
      1  -->  0
      0  -->  0
      1  -->  0
      0  -->  0
      0  -->  0
      0  -->  0
      0  -->  0
      0  -->  0
      0  -->  0
      0  -->  0
      0  -->  0
      0  -->  0
```

Boosting

In [221]:
```
XGBoost_classifier = xgboost.XGBClassifier()
```

In [222]:
```
from sklearn.preprocessing import LabelEncoder
le = LabelEncoder()
training_Labels = le.fit_transform(training_Labels)
testing_Labels=le.transform(testing_Labels)
```

In [223]:
```
XGBoost_classifier.fit(training_Features,training_Labels)
```

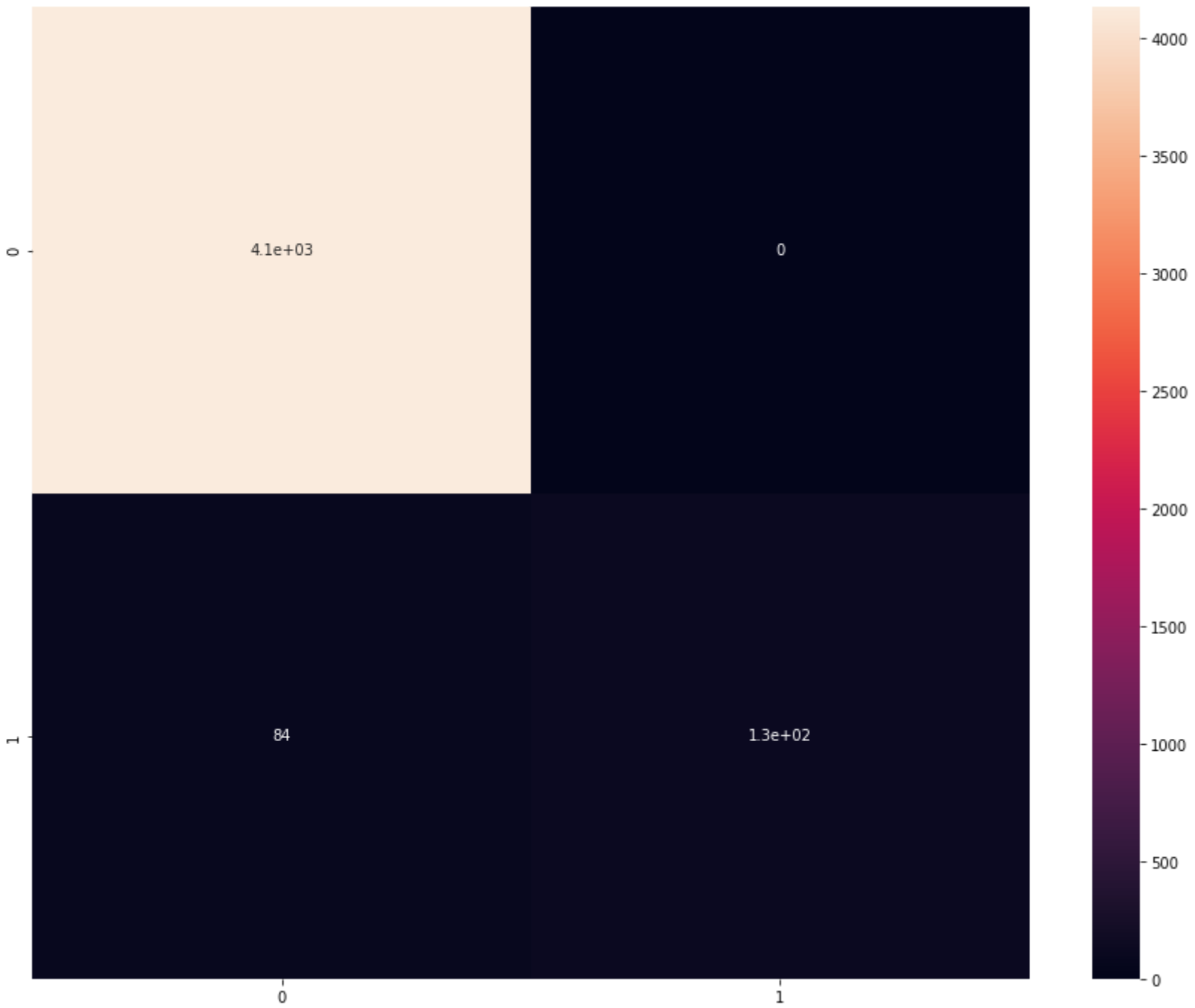
Out[223]:
```
XGBClassifier(base_score=0.5, booster='gbtree', callbacks=None,
              colsample_bylevel=1, colsample_bynode=1, colsample_bytree=1,
              early_stopping_rounds=None, enable_categorical=False,
              eval_metric=None, gamma=0, gpu_id=-1, grow_policy='depthwise',
              importance_type=None, interaction_constraints='',
              learning_rate=0.300000012, max_bin=256, max_cat_to_onehot=4,
              max_delta_step=0, max_depth=6, max_leaves=0, min_child_weight=1,
              missing=nan, monotone_constraints='()', n_estimators=100,
              n_jobs=0, num_parallel_tree=1, predictor='auto', random_state=0,
              reg_alpha=0, reg_lambda=1, ...)
```

In [224]:
```
training_predicted_values=XGBoost_classifier.predict(training_Features)
training_classification_data=confusion_matrix(training_Labels,training_predicted_values)
seaborn.heatmap(training_classification_data,annot=True)
print(classification_report(training_Labels,training_predicted_values))
```

```
              precision    recall  f1-score   support

           0       0.98      1.00      0.99      4133
           1       1.00      0.60      0.75       210

    accuracy                           0.98      4343
   macro avg       0.99      0.80      0.87      4343
weighted avg       0.98      0.98      0.98      4343
```

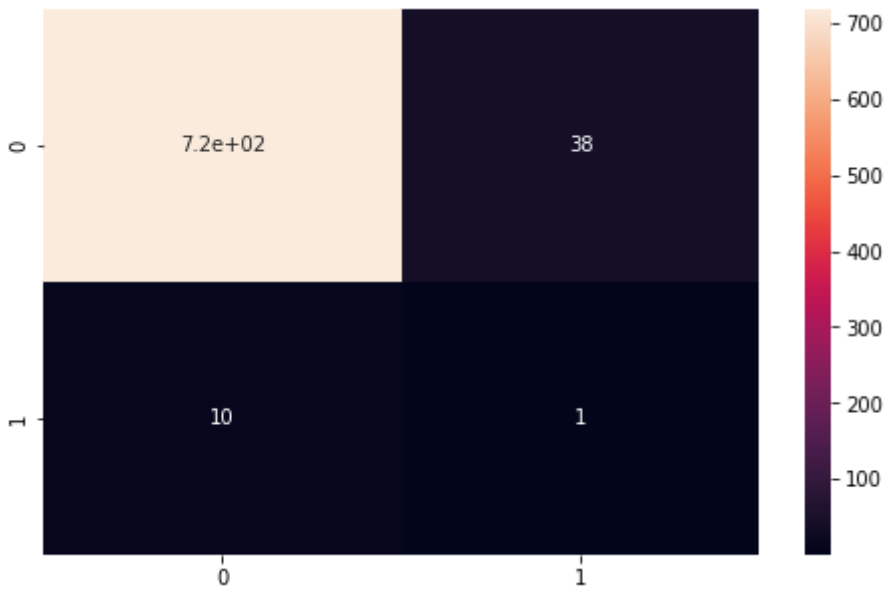


In [258]:
```
predicted_values=XGBoost_classifier.predict(testing_Features)
classification_data=confusion_matrix(predicted_values,testing_Labels)
seaborn.heatmap(classification_data,annot=True)
print(classification_report(testing_Labels,predicted_values))
```

```
              precision    recall  f1-score   support

           0       0.95      0.99      0.97       728
           1       0.09      0.03      0.04        39

    accuracy                           0.94       767
   macro avg       0.52      0.51      0.50       767
weighted avg       0.91      0.94      0.92       767
```



RandomForestRegressor (Bagging)

In [226]:
```
randomForestClassifier=RandomForestClassifier()
```

In [227]:
```
randomForestClassifier.fit(training_Features,training_Labels)
```

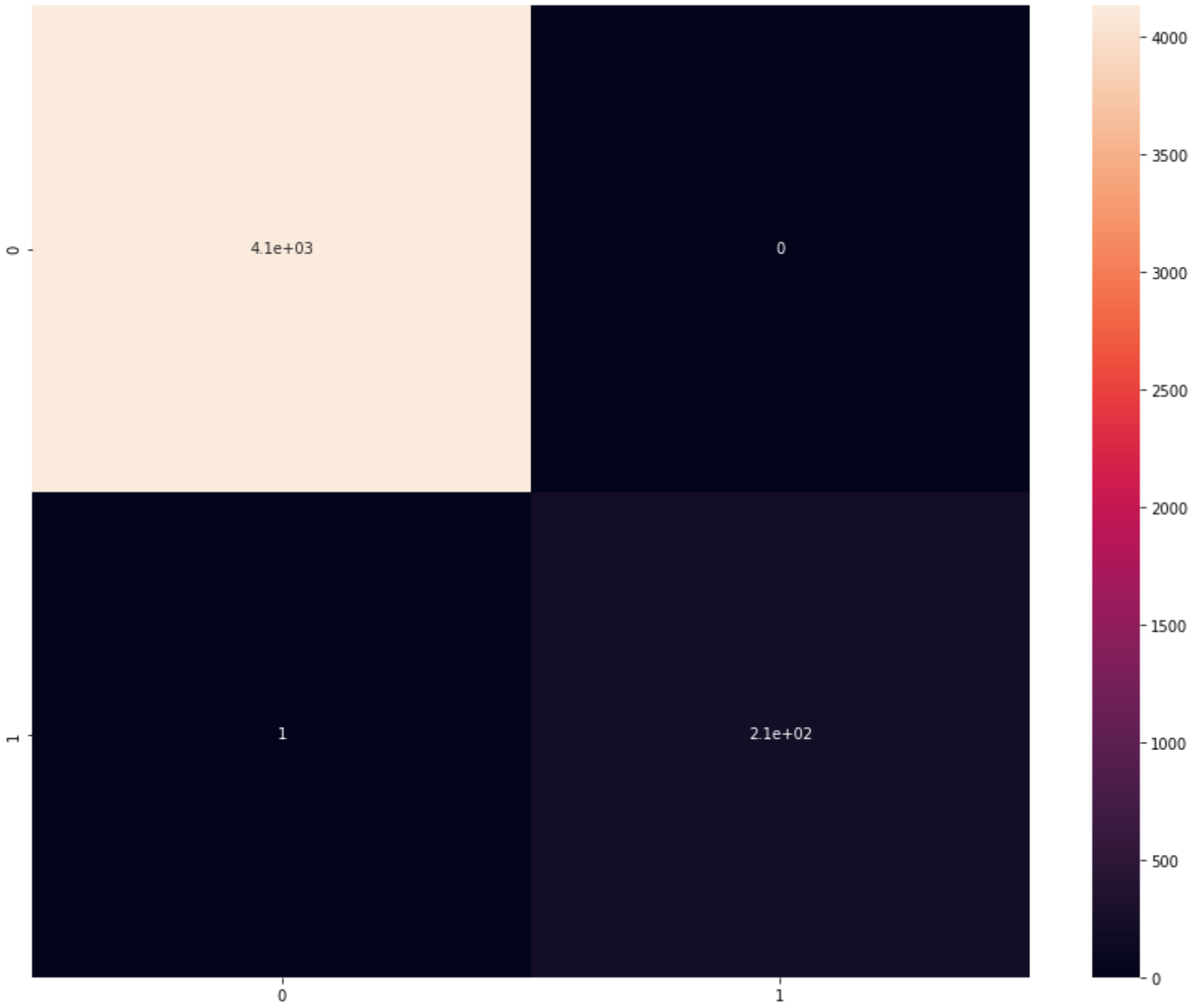
Out[227]:
```
RandomForestClassifier()
```

In [228]:
```
training_predicted_values=randomForestClassifier.predict(training_Features)
training_classification_data=confusion_matrix(training_Labels,training_predicted_values)
seaborn.heatmap(training_classification_data,annot=True)
print(classification_report(training_Labels,training_predicted_values))
```

```
              precision    recall  f1-score   support

           0       1.00      1.00      1.00      4133
           1       1.00      1.00      1.00       210

    accuracy                           1.00      4343
   macro avg       1.00      1.00      1.00      4343
weighted avg       1.00      1.00      1.00      4343
```

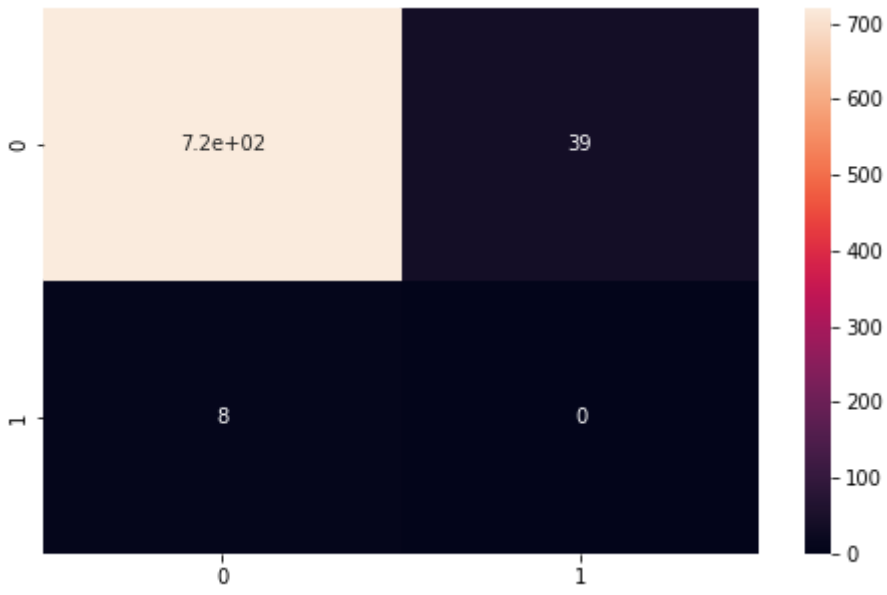


In [257]:
```
predicted_values=randomForestClassifier.predict(testing_Features)
classification_data=confusion_matrix(predicted_values,testing_Labels)
seaborn.heatmap(classification_data,annot=True)
print(classification_report(testing_Labels,predicted_values))
```

```
              precision    recall  f1-score   support

           0       0.95      0.99      0.97       728
           1       0.00      0.00      0.00        39

    accuracy                           0.94       767
   macro avg       0.47      0.49      0.48       767
weighted avg       0.90      0.94      0.92       767
```



In [ ]:
```

```

GradientBoostingClassifier

In [230]:
```
gradientBoostingClassifier=GradientBoostingClassifier()
```

In [231]:
```
gradientBoostingClassifier.fit(training_Features,training_Labels)
```

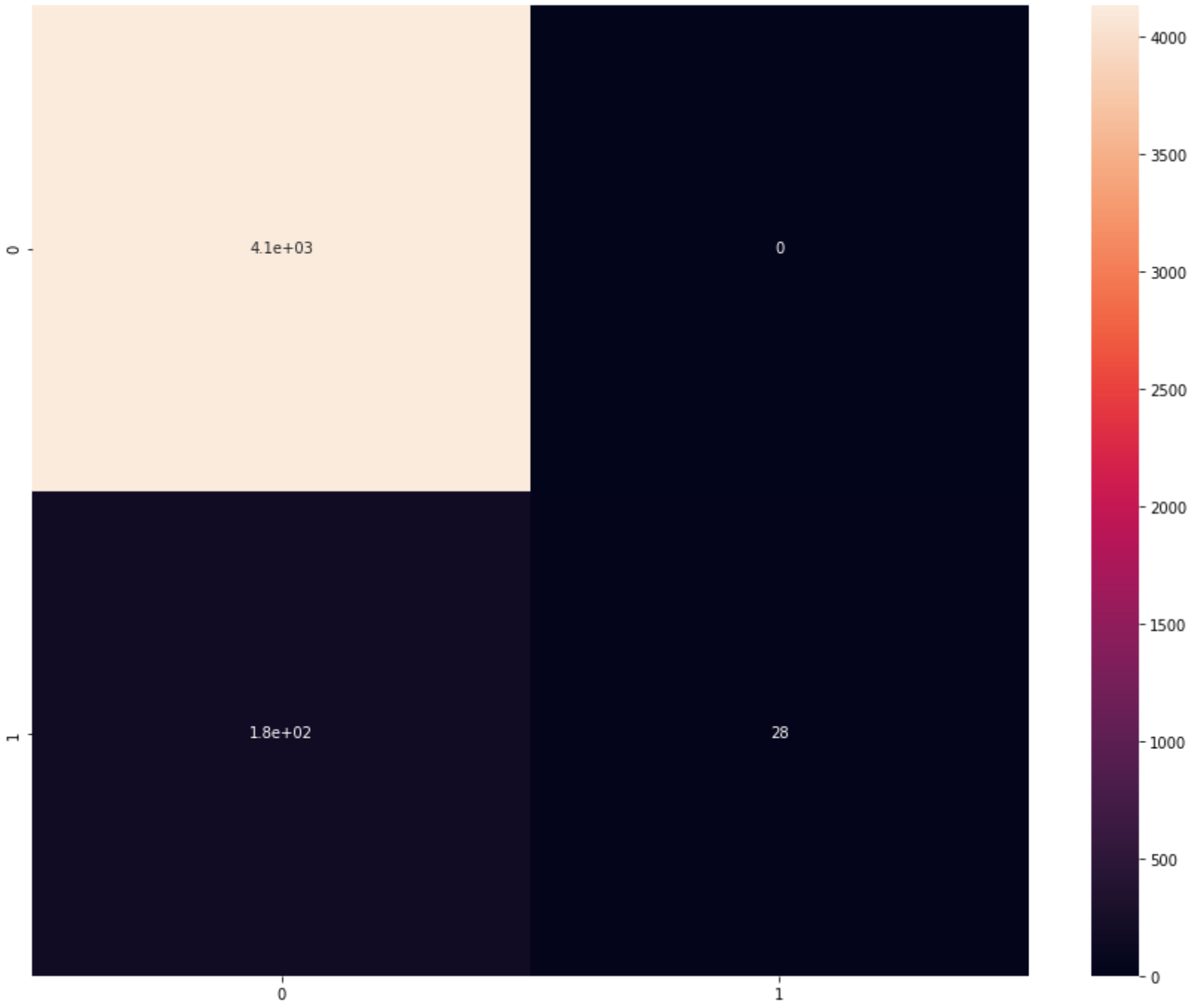
Out[231]:
```
GradientBoostingClassifier()
```

In [232]:
```
training_predicted_values=gradientBoostingClassifier.predict(training_Features)
training_classification_data=confusion_matrix(training_Labels,training_predicted_values)
seaborn.heatmap(training_classification_data,annot=True)
print(classification_report(training_Labels,training_predicted_values))
```

```
              precision    recall  f1-score   support

           0       0.96      1.00      0.98      4133
           1       1.00      0.13      0.24       210

    accuracy                           0.96      4343
   macro avg       0.98      0.57      0.61      4343
weighted avg       0.96      0.96      0.94      4343
```

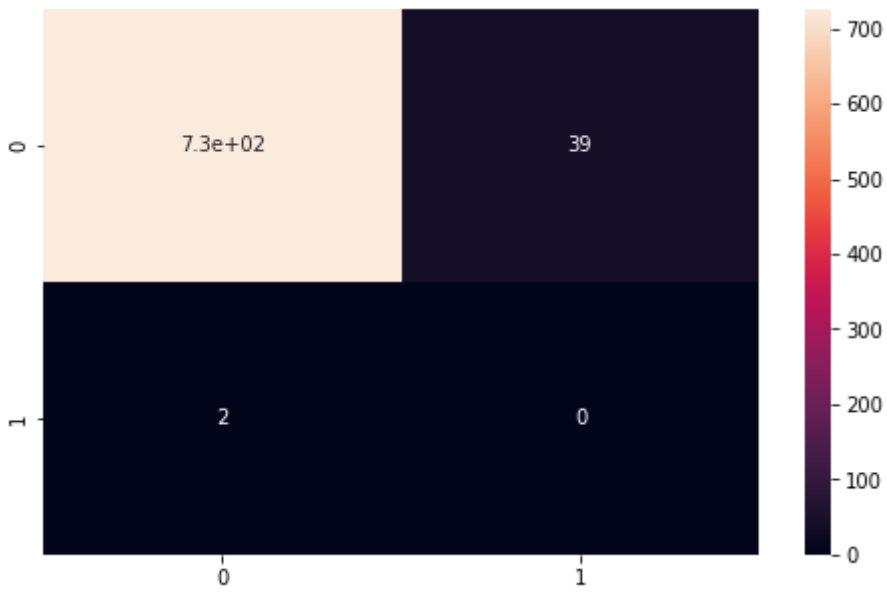


In [256]:
```
predicted_values=gradientBoostingClassifier.predict(testing_Features)
classification_data=confusion_matrix(predicted_values,testing_Labels)
seaborn.heatmap(classification_data,annot=True)
print(classification_report(testing_Labels,predicted_values))
```

```
              precision    recall  f1-score   support

           0       0.95      1.00      0.97       728
           1       0.00      0.00      0.00        39

    accuracy                           0.95       767
   macro avg       0.47      0.50      0.49       767
weighted avg       0.90      0.95      0.92       767
```



Testing on new Data 👇

for,

2. gender: "Male"
3. age: 21
4. hypertension: 0 if the patient doesn't have hypertension, 1 if the patient has hypertension
5. heart_disease: 0 if the patient doesn't have any heart diseases, 1 if the patient has a heart disease
6. avg_glucose_level: 150
7. smoking_status: "never smoked"

(Correct Output Should be Not Failed)

In [246]:
```
new_data=[1,21,0,0,150,0]
```

In [251]:
```
print(classes_list[bagging_classifier.predict([new_data])[0]])
```

```
Not_Failed
```

In [252]:
```
print(classes_list[randomForestClassifier.predict([new_data])[0]])
```

```
Not_Failed
```

In [253]:
```
print(classes_list[gradientBoostingClassifier.predict([new_data])[0]])
```

```
Not_Failed
```