In [21]:
```
import pandas as pd
import numpy as np
import imblearn
from imblearn.under_sampling import NearMiss
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import StandardScaler
from sklearn.linear_model import LassoCV
from sklearn.ensemble import RandomForestClassifier
from sklearn.neighbors import KNeighborsClassifier
from sklearn.feature_selection import SequentialFeatureSelector
from sklearn.metrics import accuracy_score, classification_report, confusion_ma
import matplotlib.pyplot as plt
```

Creating the Dataframe

In [2]:
```
df = pd.read_csv('diabetes.csv')
undersample = NearMiss(version=1)
X = df.loc[:, df.columns != 'Diabetes_binary']
y = df.loc[:, df.columns == 'Diabetes_binary']
X, y = undersample.fit_resample(X, y)


X_train, X_test, y_train, y_test = train_test_split(X, y, test_size = 0.3, ranc
scaler = StandardScaler()
scaler.fit(X_train)
X_train_scaled = scaler.transform(X_train)
X_test_scaled = scaler.transform(X_test)

df_undersampled_train = pd.DataFrame(X_train_scaled, columns = X.columns)
df_undersampled_train['Diabetes_binary'] = y_train
df_undersampled_train.head()

df_undersampled_test = pd.DataFrame(X_test_scaled, columns = X.columns)
df_undersampled_test['Diabetes_binary'] = y_test
df_undersampled_test.head()
```

Out[2]:

	HighBP	HighChol	CholCheck	BMI	Smoker	Stroke	HeartDiseaseorAttack	PhysA
0	-1.212894	0.876922	0.074482	-1.061978	1.158253	-0.225623	-0.384172	0.5
1	-1.212894	-1.140353	0.074482	0.377975	1.158253	-0.225623	-0.384172	0.5
2	0.824475	0.876922	0.074482	1.017954	-0.863369	-0.225623	-0.384172	0.5
3	-1.212894	0.876922	0.074482	0.377975	-0.863369	-0.225623	-0.384172	0.5
4	0.824475	-1.140353	0.074482	2.777896	-0.863369	-0.225623	-0.384172	0.5

5 rows × 22 columns

Creating The Wrapper Method With KNN As The Estimator

- Using both forward and backward to see which direction yields better results

In [3]:
```
sfs_forward = SequentialFeatureSelector(KNeighborsClassifier(n_neighbors=3), n_
sfs_forward.fit(X_train_scaled, y_train.values.ravel())


sfs_backward = SequentialFeatureSelector(KNeighborsClassifier(n_neighbors=3), 
sfs_backward.fit(X_train_scaled, y_train.values.ravel())

cols_idxs_forward = sfs_forward.get_support(indices=True)
cols_idxs_forward

forward_selection_train = df_undersampled_train.iloc[:, cols_idxs_forward]
print(forward_selection_train)
print(cols_idxs_forward)

cols_idxs_backward = sfs_backward.get_support(indices=True)
cols_idxs_backward

backward_selection_train = df_undersampled_train.iloc[:, cols_idxs_backward]
print(backward_selection_train)
print(cols_idxs_backward)

forward_selection_test = df_undersampled_test.iloc[:, cols_idxs_forward]
backward_selection_test = df_undersampled_test.iloc[:, cols_idxs_backward]
```

```
       HeartDiseaseorAttack  PhysActivity    Fruits  AnyHealthcare   GenHlth  \
0                 -0.384172      0.514775  0.669234       0.147309 -0.639948
1                  2.603001     -1.942597  0.669234       0.147309  1.255723
2                 -0.384172      0.514775 -1.494245       0.147309 -0.639948
3                 -0.384172      0.514775  0.669234       0.147309 -1.587783
4                 -0.384172     -1.942597  0.669234       0.147309 -0.639948
...                     ...           ...       ...            ...       ...
49479             -0.384172     -1.942597  0.669234       0.147309  0.307887
49480             -0.384172      0.514775 -1.494245       0.147309 -0.639948
49481             -0.384172      0.514775  0.669234       0.147309 -0.639948
49482             -0.384172      0.514775  0.669234       0.147309 -0.639948
49483             -0.384172      0.514775  0.669234       0.147309 -0.639948

       MentHlth  PhysHlth  DiffWalk       Sex
0     -0.332699 -0.446002 -0.485309 -1.036097
1     -0.332699 -0.446002  2.060543 -1.036097
2     -0.332699 -0.446002 -0.485309  0.965161
3     -0.332699 -0.446002 -0.485309 -1.036097
4      2.664163  0.116531 -0.485309 -1.036097
...         ...       ...       ...       ...
49479 -0.332699 -0.446002 -0.485309  0.965161
49480 -0.332699 -0.446002 -0.485309  0.965161
49481 -0.332699 -0.220989 -0.485309 -1.036097
49482 -0.332699 -0.446002 -0.485309  0.965161
49483 -0.332699 -0.446002 -0.485309  0.965161

[49484 rows x 9 columns]
[ 6  7  8 11 13 14 15 16 17]
            BMI  PhysActivity   Veggies  AnyHealthcare   GenHlth  MentHlth  \
0     -1.221972      0.514775  0.418265       0.147309 -0.639948 -0.332699
1      0.697964     -1.942597 -2.390830       0.147309  1.255723 -0.332699
2     -1.061978      0.514775  0.418265       0.147309 -0.639948 -0.332699
3     -0.581994      0.514775  0.418265       0.147309 -1.587783 -0.332699
4      1.177948     -1.942597 -2.390830       0.147309 -0.639948  2.664163
...         ...           ...       ...            ...       ...       ...
49479 -0.262004     -1.942597  0.418265       0.147309  0.307887 -0.332699
49480 -0.262004      0.514775  0.418265       0.147309 -0.639948 -0.332699
49481 -1.061978      0.514775  0.418265       0.147309 -0.639948 -0.332699
49482  0.057985      0.514775  0.418265       0.147309 -0.639948 -0.332699
49483  0.857959      0.514775  0.418265       0.147309 -0.639948 -0.332699

       PhysHlth       Sex    Income
0     -0.446002 -1.036097  0.356032
1     -0.446002 -1.036097 -2.571665
2     -0.446002  0.965161  0.843982
3     -0.446002 -1.036097  0.843982
4      0.116531 -1.036097 -0.131917
...         ...       ...       ...
49479 -0.446002  0.965161 -0.619867
49480 -0.446002  0.965161  0.843982
49481 -0.220989 -1.036097 -1.107816
49482 -0.446002  0.965161  0.843982
49483 -0.446002  0.965161  0.843982
```

```
[49484 rows x 9 columns]
[ 3  7  9 11 13 14 15 17 20]
```

Creating The Wrapper Method With Random Forest Classifier As the Estimator

- Using both forward and backward to see which direction yields better results

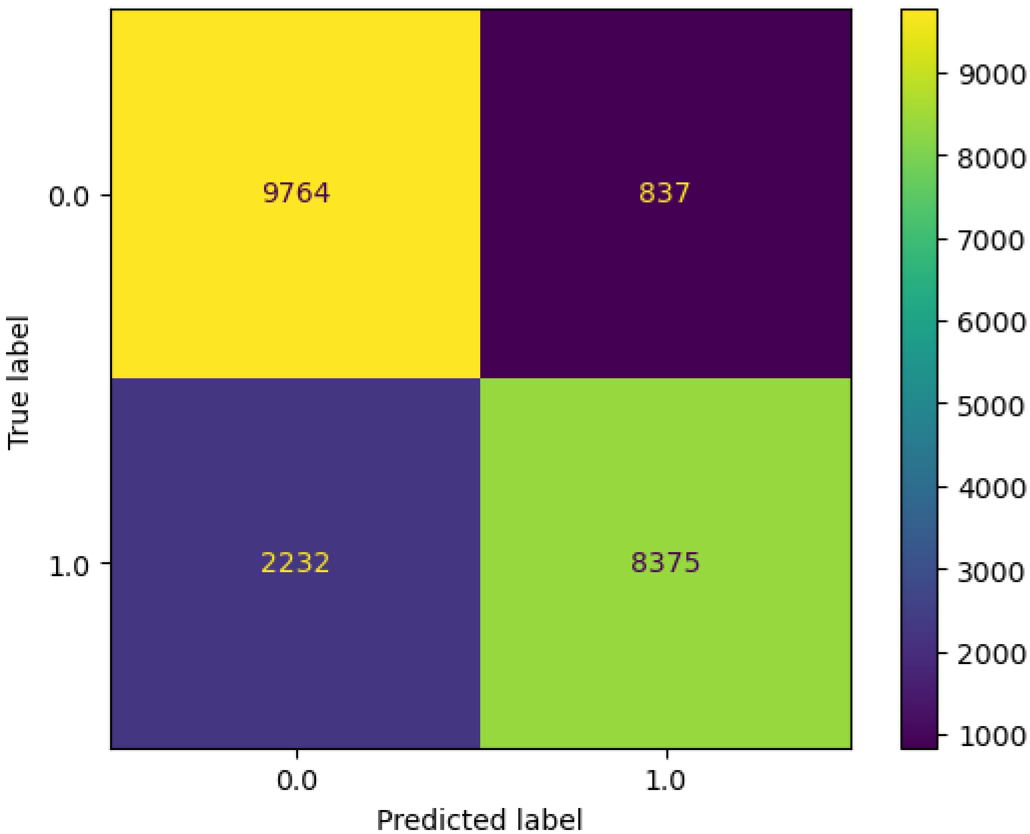
In [4]:
```
sfs_forward_rf = SequentialFeatureSelector(RandomForestClassifier(), n_feature
sfs_forward_rf.fit(X_train_scaled, y_train.values.ravel())


sfs_backward_rf = SequentialFeatureSelector(RandomForestClassifier(), n_feature
sfs_backward_rf.fit(X_train_scaled, y_train.values.ravel())

cols_idxs_forward_rf = sfs_forward_rf.get_support(indices=True)
cols_idxs_forward_rf

forward_selection_train_rf = df_undersampled_train.iloc[:, cols_idxs_forward_r
print(forward_selection_train_rf)
print(cols_idxs_forward_rf)

cols_idxs_backward_rf = sfs_backward_rf.get_support(indices=True)
cols_idxs_backward_rf

backward_selection_train_rf = df_undersampled_train.iloc[:, cols_idxs_backward_
print(backward_selection_train_rf)
print(cols_idxs_backward_rf)

forward_selection_test_rf = df_undersampled_test.iloc[:, cols_idxs_forward_rf]
backward_selection_test_rf = df_undersampled_test.iloc[:, cols_idxs_backward_r
```

```
            BMI    Stroke  HeartDiseaseorAttack  PhysActivity   Veggies  \
0     -1.221972 -0.225623             -0.384172      0.514775  0.418265
1      0.697964 -0.225623              2.603001     -1.942597 -2.390830
2     -1.061978 -0.225623             -0.384172      0.514775  0.418265
3     -0.581994 -0.225623             -0.384172      0.514775  0.418265
4      1.177948 -0.225623             -0.384172     -1.942597 -2.390830
...         ...       ...                   ...           ...       ...
49479 -0.262004 -0.225623             -0.384172     -1.942597  0.418265
49480 -0.262004 -0.225623             -0.384172      0.514775  0.418265
49481 -1.061978  4.432171             -0.384172      0.514775  0.418265
49482  0.057985 -0.225623             -0.384172      0.514775  0.418265
49483  0.857959 -0.225623             -0.384172      0.514775  0.418265

        GenHlth  MentHlth  PhysHlth    Income
0     -0.639948 -0.332699 -0.446002  0.356032
1      1.255723 -0.332699 -0.446002 -2.571665
2     -0.639948 -0.332699 -0.446002  0.843982
3     -1.587783 -0.332699 -0.446002  0.843982
4     -0.639948  2.664163  0.116531 -0.131917
...         ...       ...       ...       ...
49479  0.307887 -0.332699 -0.446002 -0.619867
49480 -0.639948 -0.332699 -0.446002  0.843982
49481 -0.639948 -0.332699 -0.220989 -1.107816
49482 -0.639948 -0.332699 -0.446002  0.843982
49483 -0.639948 -0.332699 -0.446002  0.843982

[49484 rows x 9 columns]
[ 3  5  6  7  9 13 14 15 20]
         Stroke  PhysActivity   Veggies  AnyHealthcare   GenHlth  MentHlth  \
0     -0.225623      0.514775  0.418265       0.147309 -0.639948 -0.332699
1     -0.225623     -1.942597 -2.390830       0.147309  1.255723 -0.332699
2     -0.225623      0.514775  0.418265       0.147309 -0.639948 -0.332699
3     -0.225623      0.514775  0.418265       0.147309 -1.587783 -0.332699
4     -0.225623     -1.942597 -2.390830       0.147309 -0.639948  2.664163
...         ...           ...       ...            ...       ...       ...
49479 -0.225623     -1.942597  0.418265       0.147309  0.307887 -0.332699
49480 -0.225623      0.514775  0.418265       0.147309 -0.639948 -0.332699
49481  4.432171      0.514775  0.418265       0.147309 -0.639948 -0.332699
49482 -0.225623      0.514775  0.418265       0.147309 -0.639948 -0.332699
49483 -0.225623      0.514775  0.418265       0.147309 -0.639948 -0.332699

       PhysHlth  DiffWalk    Income
0     -0.446002 -0.485309  0.356032
1     -0.446002  2.060543 -2.571665
2     -0.446002 -0.485309  0.843982
3     -0.446002 -0.485309  0.843982
4      0.116531 -0.485309 -0.131917
...         ...       ...       ...
49479 -0.446002 -0.485309 -0.619867
49480 -0.446002 -0.485309  0.843982
49481 -0.220989 -0.485309 -1.107816
49482 -0.446002 -0.485309  0.843982
49483 -0.446002 -0.485309  0.843982

[49484 rows x 9 columns]
[ 5  7  9 11 13 14 15 16 20]
```

Testing The Forward KNN Generated Feature Selection

In [22]:
```
rf_wrapper = RandomForestClassifier(criterion = 'entropy',max_features = 'sqrt
rf_wrapper.fit(forward_selection_train, y_train.values.ravel())

rfw_train_pred = rf_wrapper.predict(forward_selection_train)
rfw_train_score = accuracy_score(y_train, rfw_train_pred)
rfw_test_pred = rf_wrapper.predict(forward_selection_test)
rfw_test_score = accuracy_score(y_test, rfw_test_pred)

rfw_conf_train = confusion_matrix(y_train.values.ravel(), rfw_train_pred)
rfw_conf_test = confusion_matrix(y_test.values.ravel(), rfw_test_pred)

print(f'Random Forest Train Accuracy: {np.round(rfw_train_score, 3)} & Test Acc

print(f'Train Confusion Matrix:\n{rfw_conf_train}\n\nTest Confusion Matrix:\n{r
print(f'Train Classification Report:\n{classification_report(y_train, rfw_train

disp = ConfusionMatrixDisplay(rfw_conf_test, display_labels = rf_wrapper.classe
disp.plot()
plt.show()
```

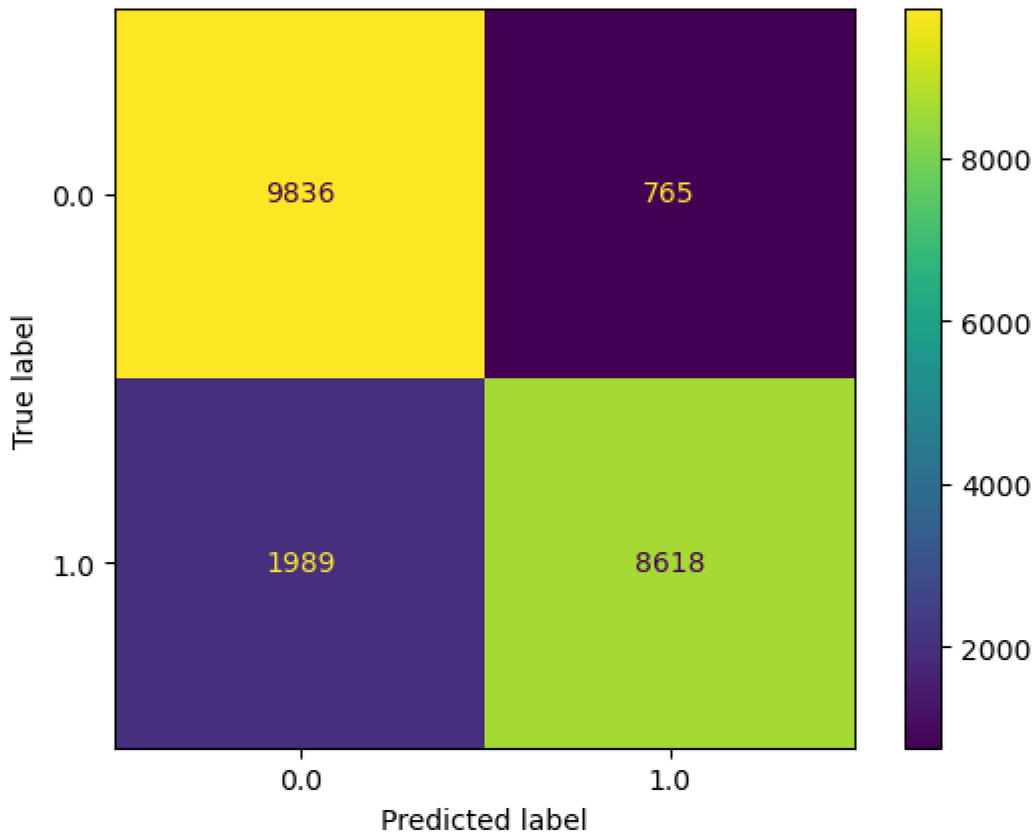
```
Random Forest Train Accuracy: 0.855 & Test Accuracy: 0.855

Train Confusion Matrix:
[[22893  1852]
 [ 5305 19434]]

Test Confusion Matrix:
[[9764  837]
 [2232 8375]]

Train Classification Report:
              precision    recall  f1-score   support

         0.0       0.81      0.93      0.86     24745
         1.0       0.91      0.79      0.84     24739

    accuracy                           0.86     49484
   macro avg       0.86      0.86      0.85     49484
weighted avg       0.86      0.86      0.85     49484

Test Classification Report:
              precision    recall  f1-score   support

         0.0       0.81      0.92      0.86     10601
         1.0       0.91      0.79      0.85     10607

    accuracy                           0.86     21208
   macro avg       0.86      0.86      0.85     21208
weighted avg       0.86      0.86      0.85     21208
```



Testing The Backward KNN Generated Feature Selection

In [24]:
```
rf_wrapper = RandomForestClassifier(criterion = 'entropy',max_features = 'sqrt
rf_wrapper.fit(backward_selection_train, y_train.values.ravel())

rfw_train_pred = rf_wrapper.predict(backward_selection_train)
rfw_train_score = accuracy_score(y_train, rfw_train_pred)
rfw_test_pred = rf_wrapper.predict(backward_selection_test)
rfw_test_score = accuracy_score(y_test, rfw_test_pred)

rfw_conf_train = confusion_matrix(y_train.values.ravel(), rfw_train_pred)
rfw_conf_test = confusion_matrix(y_test.values.ravel(), rfw_test_pred)

print(f'Random Forest Train Accuracy: {np.round(rfw_train_score, 3)} & Test Acc

print(f'Train Confusion Matrix:\n{rfw_conf_train}\n\nTest Confusion Matrix:\n{r
print(f'Train Classification Report:\n{classification_report(y_train, rfw_trai

disp = ConfusionMatrixDisplay(rfw_conf_test, display_labels = rf_wrapper.classe
disp.plot()
plt.show()
```

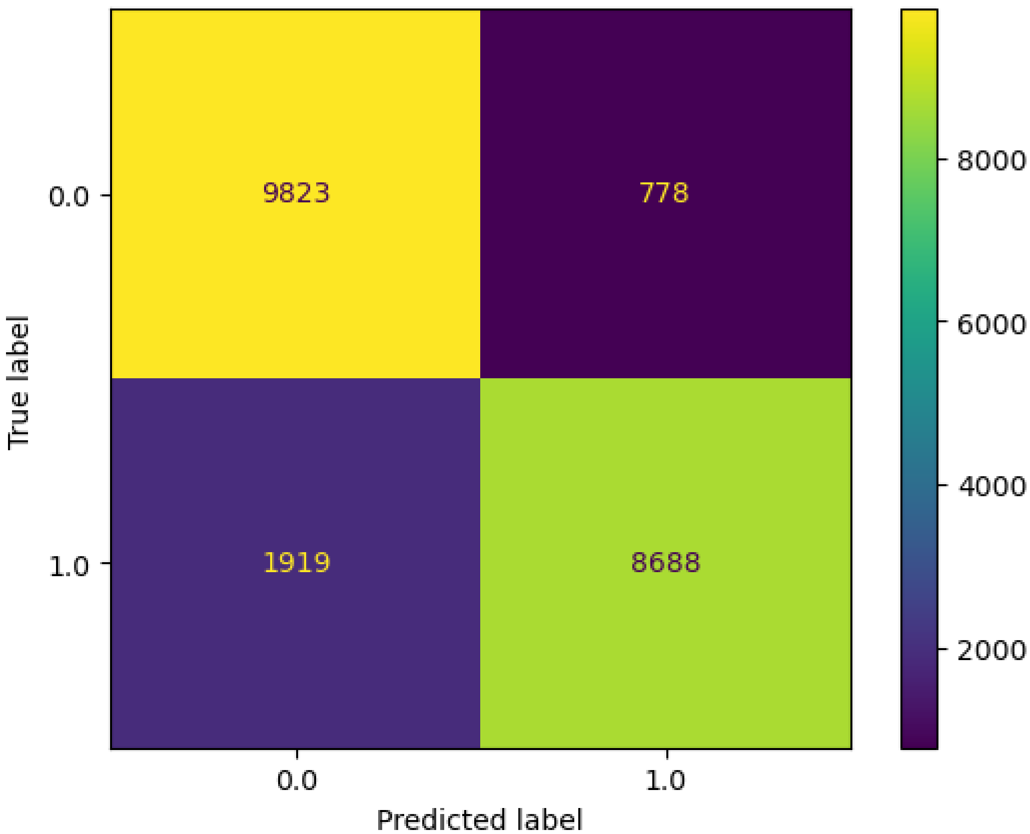
```
Random Forest Train Accuracy: 0.876 & Test Accuracy: 0.87

Train Confusion Matrix:
[[23106  1639]
 [ 4487 20252]]

Test Confusion Matrix:
[[9836  765]
 [1989 8618]]

Train Classification Report:
              precision    recall  f1-score   support

         0.0       0.84      0.93      0.88     24745
         1.0       0.93      0.82      0.87     24739

    accuracy                           0.88     49484
   macro avg       0.88      0.88      0.88     49484
weighted avg       0.88      0.88      0.88     49484

Test Classification Report:
              precision    recall  f1-score   support

         0.0       0.83      0.93      0.88     10601
         1.0       0.92      0.81      0.86     10607

    accuracy                           0.87     21208
   macro avg       0.88      0.87      0.87     21208
weighted avg       0.88      0.87      0.87     21208
```



Testing The Forward Random Forest Generated Feature Selection

In [25]:
```
rf_wrapper = RandomForestClassifier(criterion = 'entropy',max_features = 'sqrt
rf_wrapper.fit(forward_selection_train_rf, y_train.values.ravel())

rfw_train_pred = rf_wrapper.predict(forward_selection_train_rf)
rfw_train_score = accuracy_score(y_train, rfw_train_pred)
rfw_test_pred = rf_wrapper.predict(forward_selection_test_rf)
rfw_test_score = accuracy_score(y_test, rfw_test_pred)

rfw_conf_train = confusion_matrix(y_train.values.ravel(), rfw_train_pred)
rfw_conf_test = confusion_matrix(y_test.values.ravel(), rfw_test_pred)

print(f'Random Forest Train Accuracy: {np.round(rfw_train_score, 3)} & Test Acc

print(f'Train Confusion Matrix:\n{rfw_conf_train}\n\nTest Confusion Matrix:\n{r
print(f'Train Classification Report:\n{classification_report(y_train, rfw_trair

disp = ConfusionMatrixDisplay(rfw_conf_test, display_labels = rf_wrapper.classe
disp.plot()
plt.show()
```

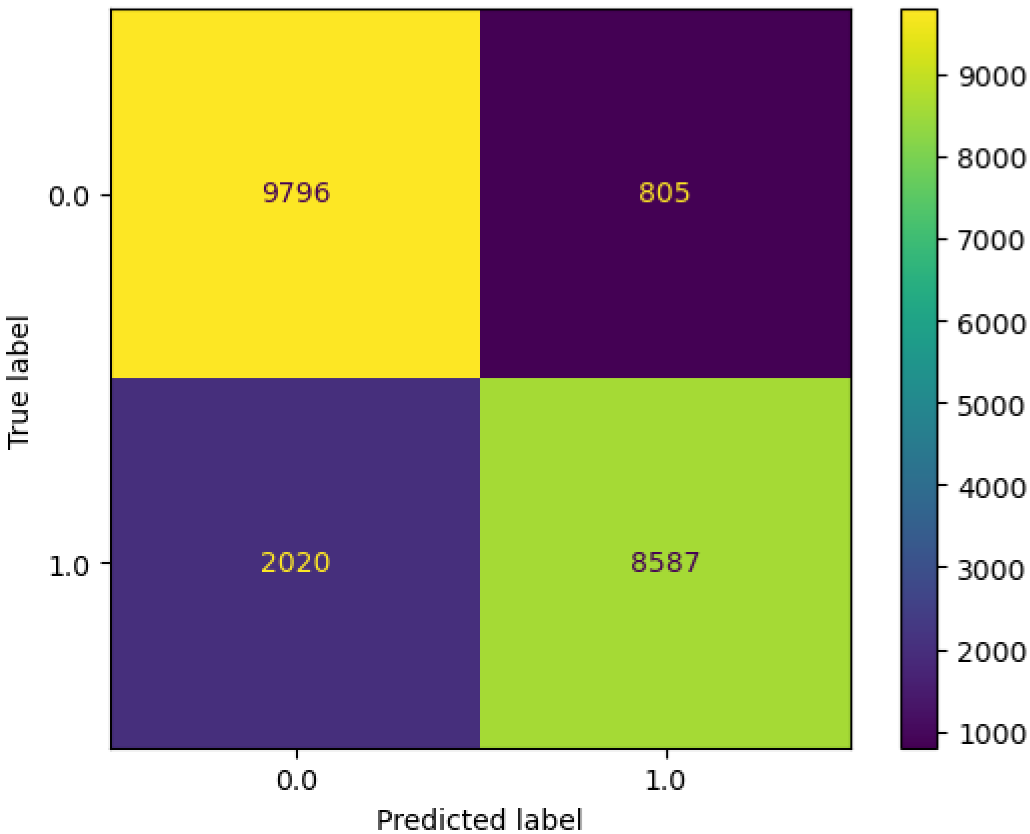
```
Random Forest Train Accuracy: 0.879 & Test Accuracy: 0.873

Train Confusion Matrix:
[[23093  1652]
 [ 4342 20397]]

Test Confusion Matrix:
[[9823  778]
 [1919 8688]]

Train Classification Report:
              precision    recall  f1-score   support

         0.0       0.84      0.93      0.89     24745
         1.0       0.93      0.82      0.87     24739

    accuracy                           0.88     49484
   macro avg       0.88      0.88      0.88     49484
weighted avg       0.88      0.88      0.88     49484

Test Classification Report:
              precision    recall  f1-score   support

         0.0       0.84      0.93      0.88     10601
         1.0       0.92      0.82      0.87     10607

    accuracy                           0.87     21208
   macro avg       0.88      0.87      0.87     21208
weighted avg       0.88      0.87      0.87     21208
```



Testing Backward Random Forest Generated Feature Selection

In [26]:
```
rf_wrapper = RandomForestClassifier(criterion = 'entropy',max_features = 'sqrt
rf_wrapper.fit(backward_selection_train_rf, y_train.values.ravel())

rfw_train_pred = rf_wrapper.predict(backward_selection_train_rf)
rfw_train_score = accuracy_score(y_train, rfw_train_pred)
rfw_test_pred = rf_wrapper.predict(backward_selection_test_rf)
rfw_test_score = accuracy_score(y_test, rfw_test_pred)

rfw_conf_train = confusion_matrix(y_train.values.ravel(), rfw_train_pred)
rfw_conf_test = confusion_matrix(y_test.values.ravel(), rfw_test_pred)

print(f'Random Forest Train Accuracy: {np.round(rfw_train_score, 3)} & Test Ac

print(f'Train Confusion Matrix:\n{rfw_conf_train}\n\nTest Confusion Matrix:\n{
print(f'Train Classification Report:\n{classification_report(y_train, rfw_trai

disp = ConfusionMatrixDisplay(rfw_conf_test, display_labels = rf_wrapper.class
disp.plot()
plt.show()
```

```
Random Forest Train Accuracy: 0.869 & Test Accuracy: 0.867

Train Confusion Matrix:
[[22934  1811]
 [ 4666 20073]]

Test Confusion Matrix:
[[9796  805]
 [2020 8587]]

Train Classification Report:
              precision    recall  f1-score   support

         0.0       0.83      0.93      0.88     24745
         1.0       0.92      0.81      0.86     24739

    accuracy                           0.87     49484
   macro avg       0.87      0.87      0.87     49484
weighted avg       0.87      0.87      0.87     49484

Test Classification Report:
              precision    recall  f1-score   support

         0.0       0.83      0.92      0.87     10601
         1.0       0.91      0.81      0.86     10607

    accuracy                           0.87     21208
   macro avg       0.87      0.87      0.87     21208
weighted avg       0.87      0.87      0.87     21208
```



Results

- Of all the directions and estimators used the best feature selection was the forward random forest sfs.

```
* The Accuracy of the features using the best model from problem 1:
    * Training: 0.879
    * Testing: 0.873

* The 9 Features that were selected are:
    * BMI
    * Stroke
    * HeartDiseaseorAttack
    * PhysActivity
    * Veggies
    * GenHlth
    * MentHlth
    * PhysHlth
    * Income
```

In [ ]: